LEARNING TASK 4

Describe the Terms Used in Platform-frame Construction

NOTES

There are many terms used with platform-frame construction. This Learning Task describes terminology related to the structure of the building, the architectural design of the building, and the spaces created by framing.

Structural Terms

The ***foundation*** is the lowest part of the building on which the walls and floors rest. Foundations are typically concrete and consist of walls and footings. They support the structure and transfer the loads to the ground.

A manufactured beam or girder may have a ***camber*** or upward curve built into it. This prevents it from sagging due to its own weight or the load it must carry. These members may be made from glue-laminated wood products, steel, or concrete.

A ***cantilever*** is the portion of a beam or joist that projects beyond its support (Figure 1).

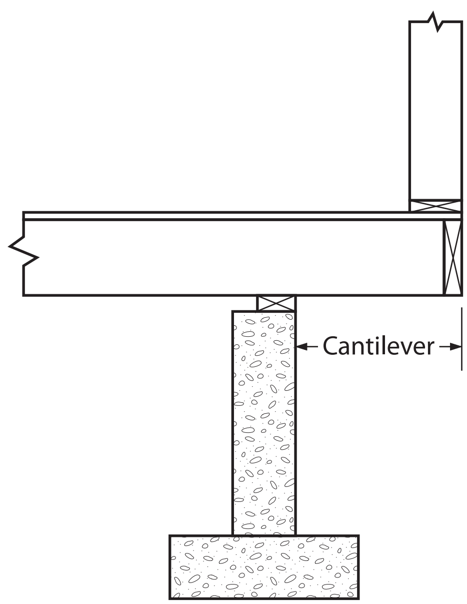


Figure 1 – Cantilevered floor joist resting on a concrete foundation

Lumber joists often warp as they dry. If the joist warps along its narrow edge, the warp is called a ***crown*** or crook. Joists should be installed with the crown up.

NOTES

Walls are used to support loads and define building spaces. Load-bearing walls carry loads such as floors or roofs. Non-load-bearing walls do not support any loads imposed on them. They may or may not be full-height walls.

- Partition walls define rooms and building spaces and may be load-bearing or non-load-bearing.
- Shear walls are used to provide lateral stability.
- Buttress walls are short walls built at right angles to the main wall. Usually longer at the bottom than at the top, they add extra support and stiffening to the wall (Figure 2).

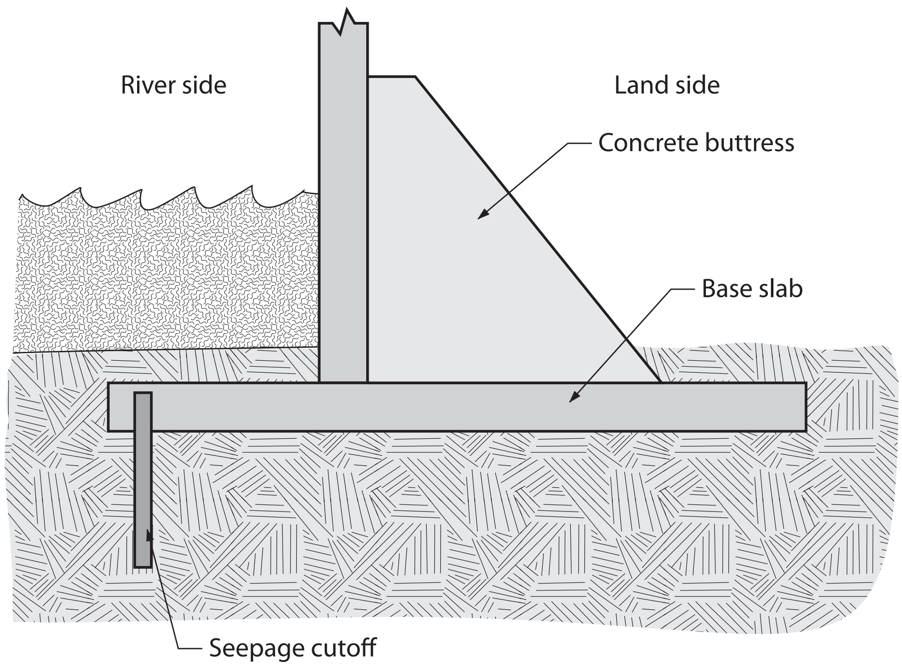


Figure 2 – Buttress wall

Breaking joints is a term used to describe staggering the joints in sheathing or top plates. A distance of four feet usually offsets the end joints of plywood sheets. According to the *Building Code*, joints in top plates must be offset by at least one stud space, but good building practice dictates an offset of two or more stud spaces.

A ***uniformly distributed load*** means that the load along a structural member, such as a beam or a bearing wall, is consistent throughout the length of the beam or wall. Uniform loads are distributed evenly and do not require framing additional to the code prescribed spacing, materials, nailing patterns, etc.

A ***point load*** is a concentrated load. For example, the bearing points that support a girder truss or beam are point loads. These points often required additional framing materials or hardware to protect wood from compression forces. For example, lintel with spans greater than 3 m require larger end bearing area. Engineers often require steel bearing plates under the bearing surfaces of girder trusses. Concentrated loads require a bearing path (load path) from top to foundation. Beam span tables within the building code may be used to size beams that have uniform loads but not for beams with concentrated loads.

Load path is the transfer of a load down to the foundation. This path is normally vertical. Where beams, lintels and cantilevers are involved the load path will move horizontally or at an angle. The bearing points of these members are a continuation of the load path to the foundation. Typically, building designers will align bearing walls or posts vertically for all floor levels throughout the structure.

Tributary width for beams and lintels is the supported joist length bearing on that member. For rafters, roof joists and trusses tributary width is the supported length which is usually half the span plus the projection.

Tributary area is the share of the structure that is being supported by a structural building component. Tributary area is used when calculating concentrated loads.

Figure 3 on the next page shows a point load on the post supporting the end of the 4 ply #2 DFir floor beam. A uniform load is along the beam itself.

The supported joist length (described in H-2 LT 2) in Figure 3 shows the tributary width of the floor bearing on the beam. It is the beam's share of the load. From the mid-point of the joist the load goes half to the beam and half to the exterior wall.

The tributary area on the posts of the deck is the product of the tributary width (the supported joist length and cantilever) and half the span of the beam on both sides of the post.

NOTES

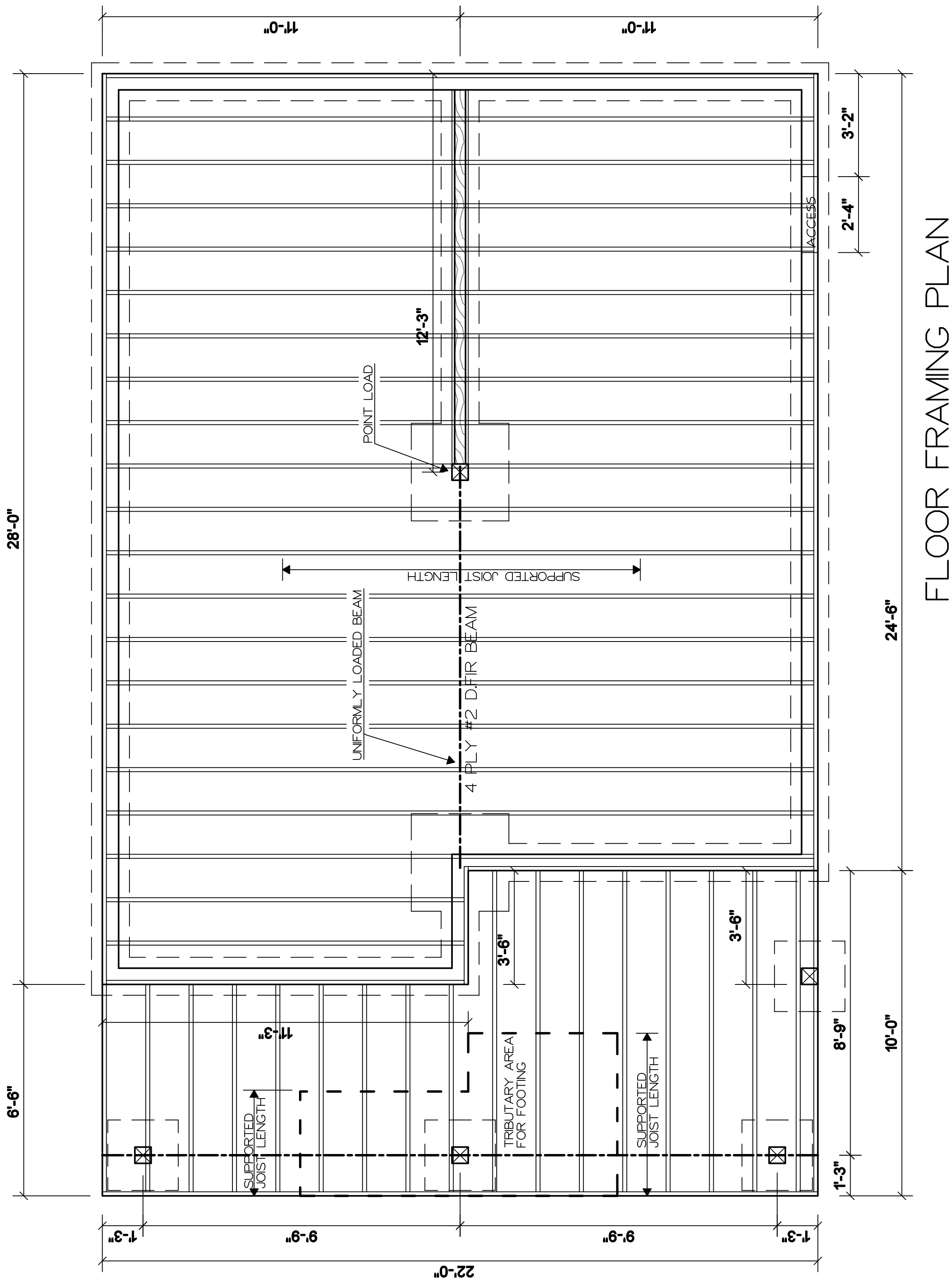


Figure 3 – Ladysmith Floor Plan Level 1

Notes

Architectural Terms

Architectural features used in framing have special names:

A ***cornice*** is the outward projection of a roof where it meets the wall. A box cornice (closed) is shown in Figure 4. An open cornice has exposed rafter tails.

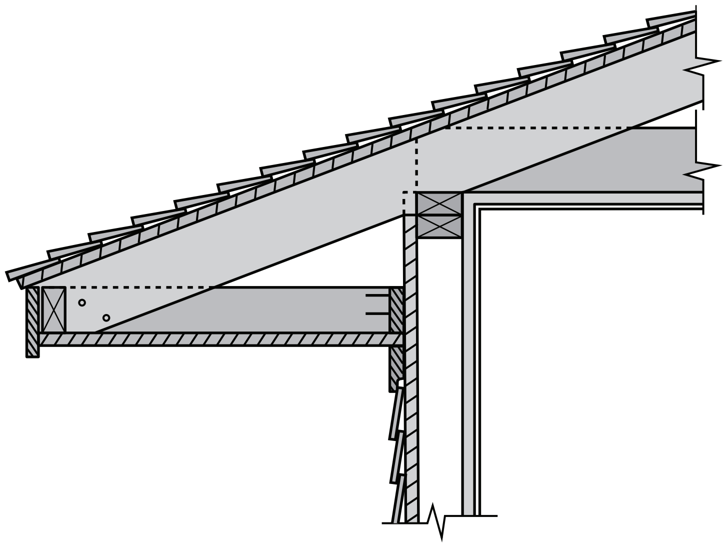


Figure 4 – Box cornice

Shed or ***gable dormers*** are projections in a roof to provide more space and light in the attic.

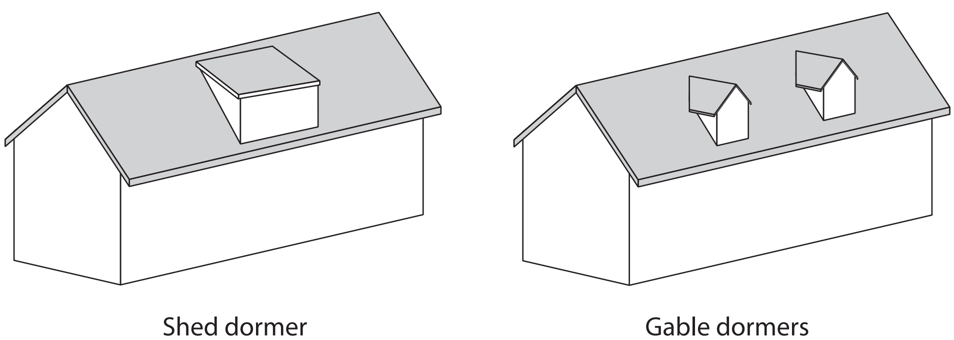


Figure 5 – Dormer types

An ***eave*** or cornice is the projection of the roof system beyond the exterior wall. It includes the fascia, gutter, rafter tails, and soffit or plancier.

The triangular-shaped end of a gable roof is called a ***gable***. The ends of cabinetwork are also called gables.

NOTES

A ***soffit*** is the underside of a building component. The "soffit" under the eaves is where the term is most commonly used, but the underside of a beam is the beam's soffit and the underside of an open stair is also referred to as the stair's soffit.

A ***parapet*** is a wall that extends above the roofline. The roof is usually flat and the parapet is used as a guard railing or for fire protection.

Spaces

The framing process creates several spaces in the structure, which have specific purposes:

Air spaces are the gaps around the ends of members entering a confined area such as a beam pocket. They allow space for air to circulate around the member, thus preventing decay.

Attic refers to the space between the upper floor ceiling and the roofing. It can also refer to an area closed off between a dwarf wall and sloping roof. Attic spaces are also known as "roof spaces."

Crawl spaces are the areas under the floor systems that are not full height. Crawl spaces may provide access for services such as heating and electrical equipment, and plumbing cleanouts. If they do, they must have a minimum clear height access way of no less than 600 mm.

Rough openings are the openings in the framing for doors, windows, stairs, or other similar items.

The size of the rough openings is critical for the component to fit properly. Obtain the correct rough opening size for doors and windows from the manufacturer or supplier before framing the opening.

Now complete Self Test 4 and check your answers.

Self Test 4

1. Do the terms "air space" and "attic" describe the same space?

2. What does the term "breaking joints" mean?

3. Explain the difference between a "crown" and a "camber."

4. What is the horizontal projection of the roof at the top of a wall called?

5. What should be done before framing the rough opening for a door or window?

6. What is a parapet wall?

LEARNING TASK 5

Describe the General Characteristics of Wood for Framing

NOTES

Wood is second only to concrete as the most commonly used building material. Most carpenters work with wood on a daily basis. Understanding its characteristics is useful when cutting, fastening, and finishing wood.

Knowing the advantages and disadvantages of wood over other materials helps carpenters to select the appropriate material for particular functions.

Advantages

Wood has many advantages over other building materials:

- renewable resource
- strength
- unique
- light weight
- easily cut
- easily fastened
- corrosion resistance
- holds finishes
- heat transfer
- electrical energy
- renovation
- reuse

Renewable Resource

Careful forest management ensures a continuous supply of trees for lumber. Trees suitable for construction lumber take from 40 to 100 years to mature to a sufficiently useful size.

Engineered building products have been developed to use the waste that accompanies sawn lumber production and to utilize smaller diameter logs. These products include particleboard, wafer board, dense fibreboard, laminated veneer lumber beams (LVL), glue laminated beams, parallel strand lumber beams (PSL), oriented strand board (OSB), and plywood. Some of these products, such as beams, are not only stronger than solid lumber, but are available in sizes that are wider and longer than the lengths sawn from a single log.

NOTES

Compared with other materials used in construction, wood is still relatively cheap and plentiful.

Strength

Wood used in construction is limited to species that are readily available. Softwood lumber (coniferous wood) such as Douglas fir, western larch, western hemlock, Pacific Coast cypress, eastern larch, jack pine, lodgepole pine, Sitka spruce, and western red cedar are the most commonly used for framing.

Wood species are grouped into different classifications of strength. To determine the lumber sizes required for specific applications, the load the member will carry and the distance between its supports must be considered. The *Building Code* provides charts and tables used to select the appropriate sized beams and joists. These design tables are based on the strengths of various species and grades of softwoods available in British Columbia.

Unique

Different species of wood are used for different purposes, and within each species, every piece of wood is unique. No two pieces are exactly alike in strength, colour, or markings. This gives wood a natural decorative quality.

Sawn lumber is cut from logs. Each piece of sawn lumber needs to be graded individually because of its unique nature.

Light Weight

Compared with building materials such as steel and concrete, wood is light in weight. For example, wood has a density of approximately 500–600 kg/m^3 whereas steel has a density of 8000 kg/m^3 and concrete 2400 kg/m^3. For any given volume, wood is much lighter than many other building products.

Wood's light weight makes it easy to work with. Small wooden members are easily handled. The light weight of kiln-dried lumber reduces shipping costs.

Easily Cut

Wood is easily cut, drilled, and shaped. Wood can be cut with hand or power tools. Common tools include handsaws, planes, wood chisels, portable circular saws, and routers. Steel and concrete are more difficult to cut and shape.

Easily Fastened

Wood is easily and securely attached to other wood members by using common nails. When bolts are required, holes can be drilled to accommodate them.

Screws used in softer woods may not require a pilot hole (harder woods should have a pilot hole to align the screw and make it easier to place). Since glues and adhesives are readily absorbed by wood, they're a good method of fastening wood in certain applications.

NOTES

Corrosion Resistance

Wood is neutral—it will not react with corrosive materials such as acids and alkali. Metals such as steel, copper, and aluminum are susceptible to oxidation and corrosion, which will eventually weaken the material.

Holds Finishes

Wood is easy to paint, stain, and varnish. It will hold a finish very well if it's clean and dry when the finish is applied. Most woods have a distinctive grain, which will be more pronounced with the use of stains and varnishes or other finishes such as oils. Both oil base and latex base paint can be used on wood for interior or exterior purposes.

Heat Transfer

Compared to steel or concrete, wood is a good insulator. The interior of wood window trim members will not "sweat" with condensation when exposed to extreme differences in temperature.

Electrical Energy

When working around electricity, wood ladders are used because wood is a poor conductor of electrical energy.

Renovation

Alterations of wooden structures are easy. Wood framing can be cut out or added onto with little trouble. Structures made of materials such as concrete block, steel, or concrete are far more difficult to renovate.

Reuse

Wooden members in a building can be reused during alterations or salvaged for reuse when buildings are demolished. If wood is to be reused, precautions should be taken during the dismantling process to avoid damaging the members. Nails should be removed with care, and finishing nails should be pulled from the backside to prevent damage to the face of the stock.

NOTES

Disadvantages

Although wood has many valuable qualities, there are also disadvantages:

- swelling and shrinking
- decay
- flammable
- non-uniform
- cracks

Swelling and Shrinking

Wood swells or shrinks in both width and thickness when the moisture content in the atmosphere changes. There is very little change to the length of a board due to changes in moisture content.

The relationship between wood and moisture is significant—virtually all the physical properties of wood are affected by the amount of moisture the wood contains at any given time. Wood readily absorbs water in both liquid and vapour form because of its cellular structure. Some species of wood can absorb two or three times their own weight in water.

Decay

When conditions are unfavourable, such as lack of ventilation or exposure to dampness, wood becomes part of the food chain. These conditions makes wood subject to rot organisms and insect invasion.

Wood can be protected with chemicals, or by keeping it dry and well ventilated. When wood is used below grade or for exterior work, it must be treated with chemicals to prevent decay. These chemicals are readily absorbed by wood. They include paints, stains, alkaline copper quaternary (ACQ), and copper azole (CA).

Flammable

Wood catches fire readily, and once a wooden frame structure is on fire, its wood members will be a constant source of fuel. Wooden structures can be made fire-resistant by using other materials over the wood, such as plaster or gypsumboard panels.

Although flammable, large beams of wood take time to burn through and will support their load long after a steel beam has failed. (While steel is not flammable and much stronger than wood, when exposed to high temperatures it loses its strength sooner than wood.) Due to the nature of their construction, wooden I-joists lose strength very quickly when on fire.

Notes

Non-uniform

The manufacture of products such as steel and concrete is carefully controlled—this gives these materials a very uniform strength.

Solid wood is not uniform. It's not manufactured; it's grown. The tree's location and exposure to weather greatly affect its properties. Wood grown on a hillside develops tension on the uphill side and compression on the downhill side. This can cause lumber to warp and twist.

Trees have branches. Every branch creates a knot in the wood. Loose knots cause weakness in a board and may cause it to break.

The growth rate of the tree varies. When growing slowly, the wood is strong and dense, but when growing quickly, the wood is weak and light.

Cracks

Drying and nailing are two of many reasons wood may crack or split. Cracked wood is usually weaker and fasteners may not have much holding strength if the wood splits.

Now complete Self Test 5 and check your answers.

Self Test 5

1. What is the density of wood, steel, and concrete?

2. Why does using wood for window frames reduce condensation on the inside surfaces?

3. How can wood be reused? How do you prepare wood for reuse?

4. How long does it take for wood to mature to a size that it can be harvested for lumber production?

5. List five engineered building products.

6. What happens to wood when exposed to atmospheric changes?

7. Which holds its strength longer in fire situations, wood or steel?

LEARNING TASK 6

Describe Lumber Production

NOTES

Most saw mills are computer-operated. The computer program associated with the saw measures the log and, with the operator's help, determines its defects. The log is then cut to produce the maximum amount of saleable lumber.

Current trends in the lumber market often dictate what dimension lumber is cut to. If offshore sales are slow, more dimension lumber is cut. If the offshore market is up, larger "cants" are cut. The cants are shipped to other countries, where they are resawn.

Half of the lumber produced in British Columbia comes from logs with a diameter under 9". Only 7% of the logs cut into lumber are over 21" in diameter.

Sawing Methods

Before logs are milled, they're washed with high-pressure jets and then debarked. Lumber is cut from the log in many different ways. Different cutting methods produce different types of grain patterns. The amount of shrinkage that occurs during drying will vary depending on how the lumber is cut.

Many mills cut framing lumber into large slabs. Using a gang, the slabs are resawn into multiple boards in one pass.

Grain

Two types of wood called "springwood" and "summerwood," form annual growth rings. Spring wood grows fast and is porous. Summerwood grows much slower and is quite dense.

The grain pattern on the face of the board appears as irregular lines that form "mountains" or "cathedrals" of summerwood. Lumber cut to produce flat grain will wear unevenly. The large areas of soft springwood will wear away before the hard summerwood.

Edge Grain Lumber

Edge grain lumber will shrink less across its width than flat grain lumber of the same width. Lumber cut to produce edge grain will resist wear better than lumber with flat grain.

NOTES

To be classified as an edge grain board, the angle formed by the annular growth rings must form an angle greater than 45° to the face of the board (Figure 1).

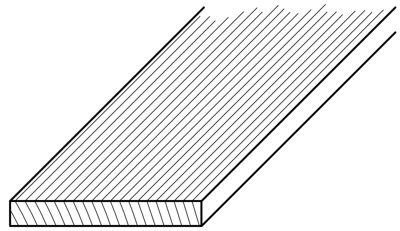


Figure 1 – Edge grain lumber

The grain pattern on the face of the board appears as relatively straight lines that are parallel to the edge of the board.

Flat Grain Lumber

Flat grain lumber will shrink more across its width than edge grain lumber of the same width.

The angle formed by the annular growth rings and the face of the board is less than 45° for flat grain boards (Figure 2).

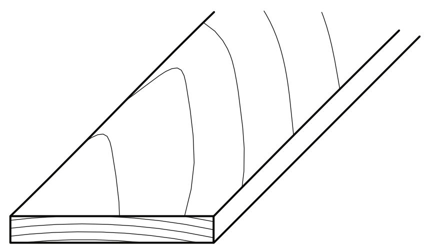


Figure 2 – Flat grain lumber

Flat grain lumber is more likely to cup than edge grain lumber.

Flat or Plain Sawn Lumber

The simplest way to cut a log into boards is to cut boards through the full width of the log (Figure 3).

Most of the boards produced by plain sawing will have flat grain.

This is a common sawing method for the production of framing lumber.

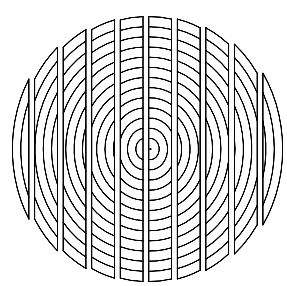


Figure 3 – Plain-sawn lumber

NOTES

Quarter-sawn Lumber

Cutting the log into quarters first and then cutting each quarter into boards will produce boards that are all edge grain (Figure 4).

Quarter-sawing is more difficult and only used where the edge grain characteristics are needed.

This method is mainly used to produce high-end finishing lumber.

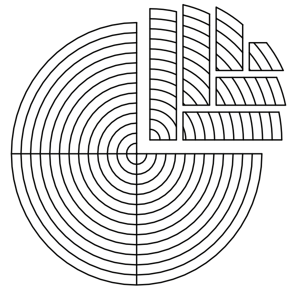


Figure 4 – Quarter-sawn lumber

Drying

When lumber is sawn from a freshly cut log, it may have a moisture content of 45% or more. Fresh cut lumber is considered "green" until it's dried. The *BC Building Code* requires the moisture content of framing lumber to be no greater than 19%. Framing lumber is either kiln-dried or air-dried.

S-DRY

Lumber is kiln-dried in a large steam oven. This creates even drying from the inside out. When lumber is kiln-dried, it's surfaced after it's dry. "S-DRY" is included in the grade stamp to indicate that it was surfaced after it was kiln-dried.

S-GRN

When framing lumber is air-dried, it's surfaced before it's dry and the grade stamp will include "S-GRN" to indicate that it was surfaced green. Lumber that's surfaced green is surfaced to a slightly larger dimension than lumber that's surfaced dry. This allows for the eventual shrinkage that will occur when the lumber dries. Since all logs are not at the same moisture content when sawn, this will cause a slight variation in lumber size between different boards. One method to counteract this is to float the logs in a mill pond before sawing.

Surfacing

Rough sawn lumber is surfaced by machining it on its four surfaces. The planer is able to surface all four sides at once. Special planer heads are used to produce textures such as comb-face.

NOTES

Abbreviations

Dressed lumber has been sawn and planed smooth on at least one surface. A standard set of abbreviations is used to indicate how many sides or edges have been dressed:

S1S	surfaced one side
S2S	surfaced two sides
S1E	surfaced one edge
S2E	surfaced two edges
S1S2E	surfaced one side and two edges
S2S1E	surfaced two sides and one edge
S4S	surfaced on all four sides

Standard framing lumber is S4S.

Re-sawn Boards

Boards used as wall sheathing or form sheathing are usually S1S2E. These 1" boards are re-sawn from S4S 2" material.

There is normally not much demand for 2×8 and 2×10 lumber that is graded as #3 or Utility. These poorer grade planks are often re-sawn into ¾" boards, where they are used as sheathing or fencing. Sometimes top quality planks are resawn to produce a slightly rough texture for exterior trim boards.

The planks are cut in half across their width with a band saw. This changes a S4S plank to two S1S2E boards.

Grading

Softwood lumber used for construction is graded by two methods: visual grading and machine stress rating. Information on lumber grading is covered in Learning Task 9 of this Competency.

Treatment

Most framing lumber is packaged in standard lift loads. Because the lumber is packaged tightly and because moisture is usually present, lumber is often surface treated at the mill to give cosmetic protection from mould and sap stains.

Pressure-treated

Lumber used for fences, decks, and other outdoor uses is often pressure-treated. Most pressure-treated fence lumber is treated with alkaline copper quaternary (ACQ). Chromated copper arsenate (CCA) is no longer used, except for special cases, as it contains arsenic.

Lumber is submerged in a chemical bath in a large chamber, which is then pressurized to force the chemicals into the lumber and not just onto the surface. The chemicals protect against fungi that cause rot and against wood-eating insects such as termites.

The depth of chemical penetration can be seen when a piece of pressure-treated wood is cut on the job site. It's important to treat all cut ends to maintain the effectiveness of pressure treatment.

Now complete Self Test 6 and check your answers.

NOTES

Self Test 6

1. Which type of sawing produces the most "flat grain" lumber?

2. Which type of sawing produces the most "edge grain" lumber?

3. What angle must the grain be to be considered edge grain?

4. Describe "plain sawing."

5. Which abbreviation is used for 1×10 re-sawn boards?

6. What does "S-GRN" stand for?

LEARNING TASK 7

Describe the Characteristics of Softwood Species

Notes

Trees are divided into two classes: hardwoods and softwoods. Hardwoods come from deciduous trees, which have broad leaves. Softwoods are from coniferous (cone-bearing) trees, which have very narrow leaves called "needles."

Tree Parts and Their Functions

A tree consists of roots, trunk, and crown (Figure 1).

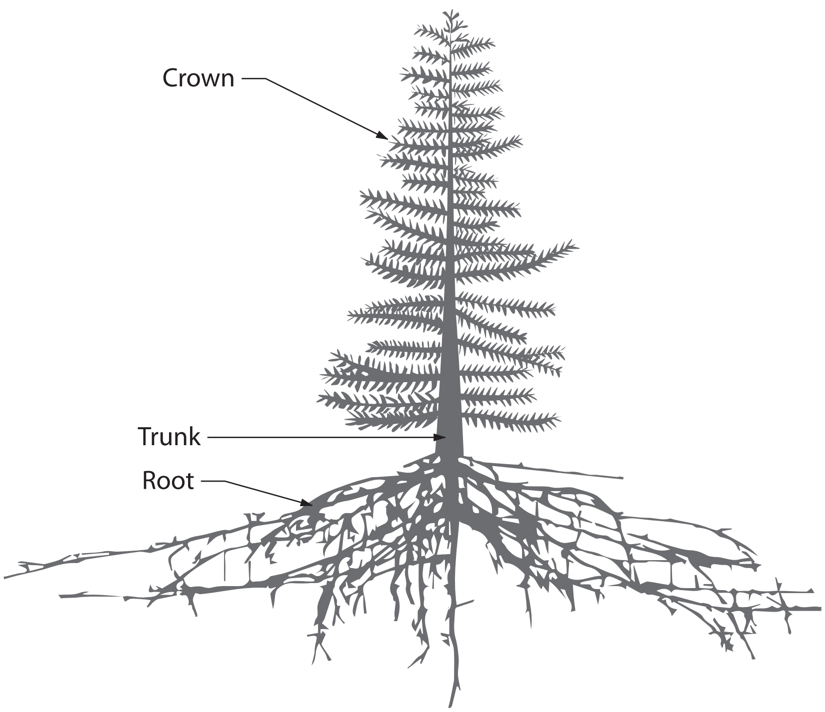


Figure 1 – Tree parts: roots, trunk, and crown

Crown

The crown of the tree is composed of branches and leaves (needles). It's in this part of the tree that the food required for growth is manufactured. Energy from the sun is collected through the leaves and combined with water and carbon dioxide to make simple sugars in a process known as "photosynthesis." These simple sugars are then transported to other parts of the tree to fuel the life and growth processes.

NOTES

The crown may consist of only the top 15% of the tree or it may extend farther down. If the branches cover the entire tree height, then it's considered to have 100% crown. The more crown a tree has, the faster it will grow, resulting in logs with more taper and more knots. Knots are formed as the trunk grows around branches. If the branches are dead when this happens, the knots may become loose once the trunk is milled into lumber.

Roots

The roots of the tree perform two functions: they anchor the tree in the soil to help it withstand wind and gravity, and they absorb moisture and nutrients. Damage to the root system can kill the tree.

Trunk

The trunk of the tree is also referred to as the "stem." Its main functions are to provide structural support for the crown and transport food and moisture from the roots to the crown. Unlike humans, whose legs get longer as they grow, trees grow from the top up and the sides out. Because of this, a branch that is 2 metres above the ground remains at 2 metres as the tree grows.

The trunk is the part of the tree that's sawn into lumber or peeled for veneer to make plywood, OSB, or other engineered products.

The trunk is composed of eight distinct types of wood structure:

- outer bark
- inner bark
- cambium layer
- sapwood
- heartwood
- pith
- rays
- annual growth rings

Each structure plays an important role in the growth and maintenance of a tree and determines, to a large extent, the characteristics of lumber sawn or peeled from a particular species.

Outer Bark

The outer bark protects the tree from pests, disease, and damage. It consists of layers of corky material. The outer bark's thickness ranges from as little as a fraction of a millimetre to as much as 300 mm.

NOTES

The outer bark is composed of dead cells and becomes brittle and dry with time. This gives the outer layer a scaly, fissured appearance. Deep cracks and fissures form in the outer bark of softwoods. The outer bark is formed by the inner bark changing to outer bark. In this way, the bark expands to accommodate new growth in the diameter of the tree.

Inner Bark

The inner bark of the tree performs two important functions: It provides new material to add to the outer bark, and it contains special tube-like cells that carry sugars and proteins manufactured in the leaves down to mix with the water and nutrients coming up from the roots.

Cambium Layer

The cambium layer is made up of an extremely thin region of living cells located between the inner bark and the sapwood. It's in this region that the cells making up the bulk of the tree are formed. These cells are used by the tree to create new sapwood and new inner bark.

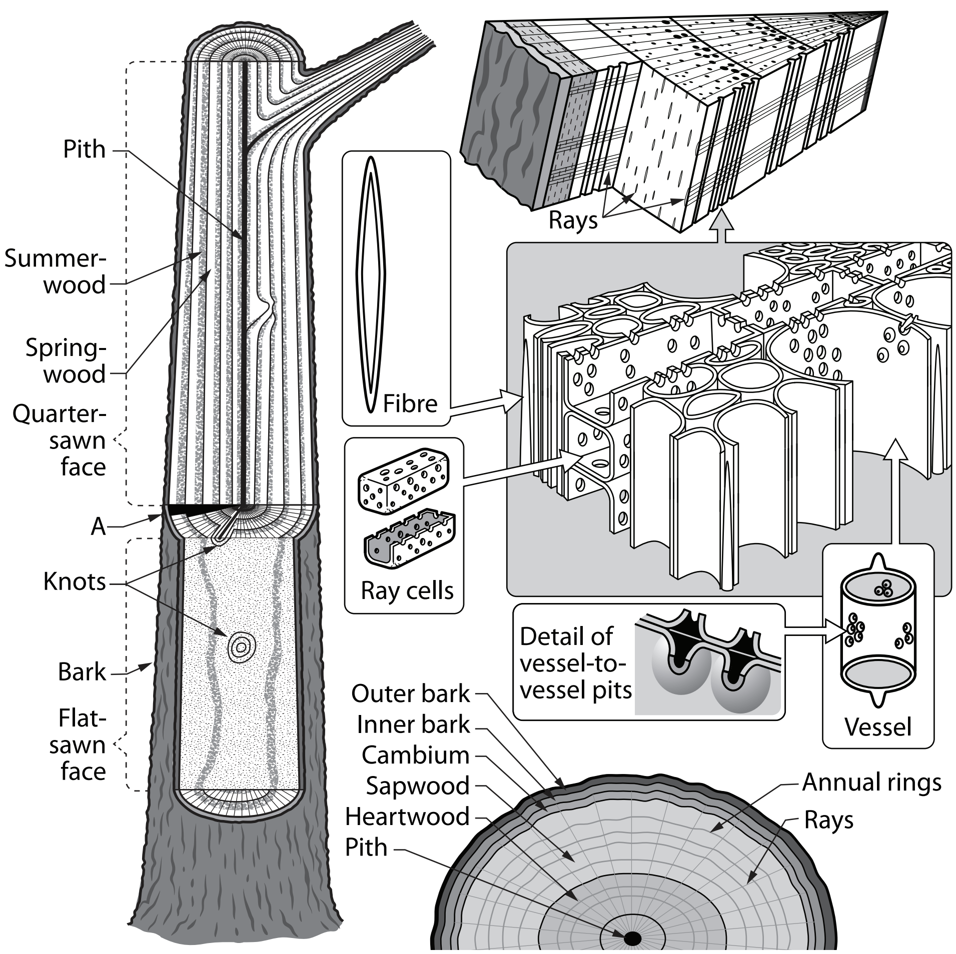


Figure 2 – Structure of a tree trunk

NOTES

Sapwood

The sapwood region of the tree is located between the heartwood and the cambium layer and consists of light-coloured wood. The main function of sapwood is to carry sap, water, and nutrients from the roots to the leaves and cones.

In softwood trees, specialized cells called "tracheids" are arranged in staggered layers as illustrated in Figure 3. When there is a demand for moisture in the leaves, natural conduction draws sap upward through the tree, from cell to cell. The sap passes from cell to cell through tiny openings in the cell wall called pits.

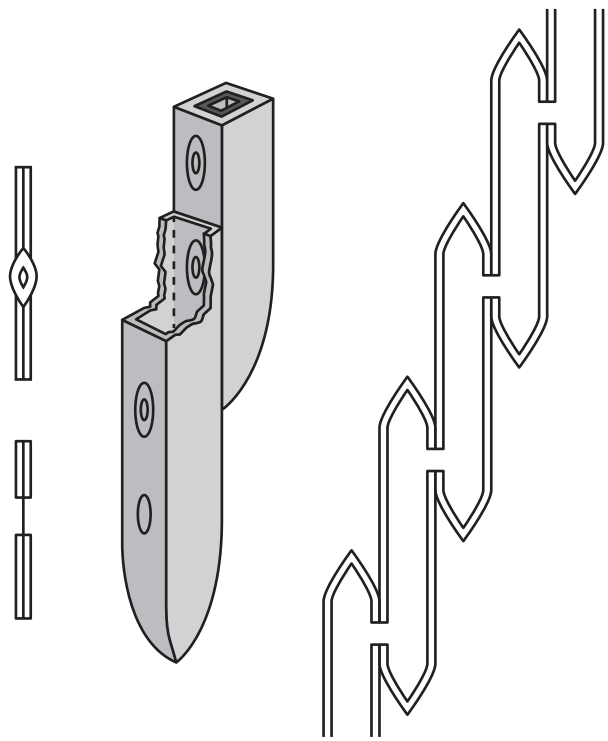


Figure 3 – In softwoods, sap moves from cell to cell through tiny openings called pits

Heartwood

Each year a small portion of sapwood is converted to heartwood. Heartwood consists of dead cells, which are formed by a series of chemical changes in the sapwood. The heartwood's colour deepens as the natural tannins and resins darken. These tannins and resins make the heartwood more durable and less susceptible to decay.

The main function of the heartwood is to give structural support to the tree. The wood becomes stronger as cell walls harden with the loss of sap.

NOTES

Pith
The first growth in newly formed twigs takes place around soft tissue called the pith. Pith consists of dead cells. The soft nature of pith can seriously affect the value and quality of lumber used in finishing. However, pith does not affect the structural strength of the wood used for framing and other purposes.

Rays
Rays are long narrow structures that appear as fine lines on the surface of a cross section of a tree trunk or branch. Unlike the structures discussed above, the cells of rays are arranged horizontally rather than vertically in the tree. A typical ray arrangement is shown in the enlarged view of a cube of softwood in Figure 4.

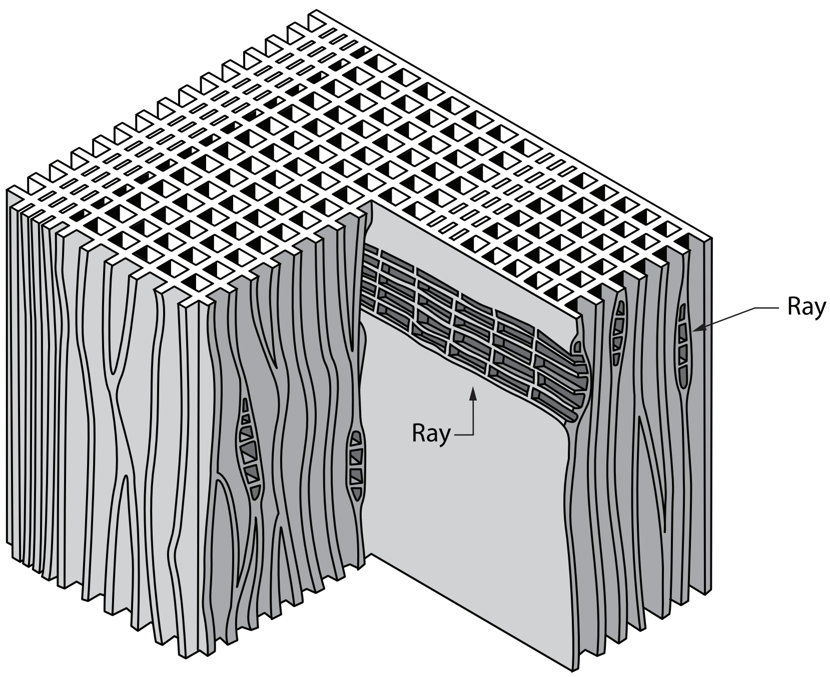


Figure 4 – Rays are arranged horizontally

Ray cells are arranged horizontally in the wood to conduct food and moisture laterally across the tree trunk. Rays originate at the centre of the tree in the sapwood or heartwood and extend to the inner bark, which is the source of food and moisture.

The appearance of rays varies according to the direction from which they are viewed. On the transverse or cross-sectional plane, they appear as long lines. On the tangential plane, they look like narrow slits. On the radial plane, they appear as flecks or chips (Figure 5).

NOTES

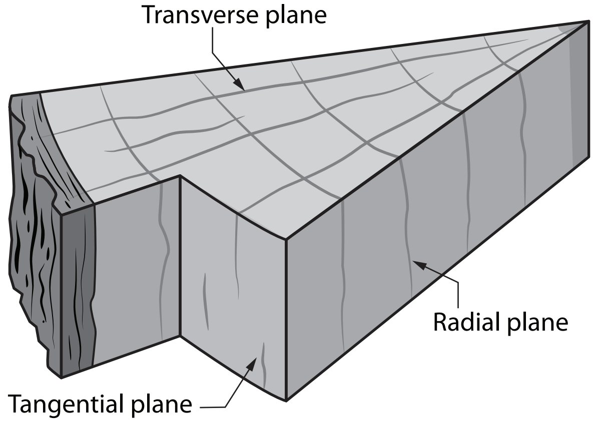


Figure 5 – The appearance of rays depends on the direction from which they are viewed

Rays are more defined in some woods than in others. In oak, for example, the rays are the predominant feature when the wood is quarter-sawn.

Annual Growth Rings

During the growing season, a new layer of wood is added to the diameter of the tree, and in many species, these layers of growth are readily apparent as annual growth rings. Since a new ring is added each year, the age of a tree can be determined by making a cross-sectional cut near the base of the trunk then counting the rings, or by drilling the tree with an increment bore.

Two types of wood called springwood and summerwood form annual growth rings. Springwood (which is also called "earlywood") is formed in the early part of the growing season when growth takes place rapidly. Springwood is characterized by large, thin-walled cells, and the material is more porous and weaker than wood formed later in the season. Summerwood (which is also called "laterwood") is produced during late summer, fall, and winter when there is a slower rate of growth. As a result, this wood consists of small, thick-walled cells and is greater in density and strength than springwood. Summerwood tends to be darker than springwood.

In some species of wood, the distinction between springwood and summerwood is definite, and the annual rings are easy to see. In tropical climates, where the seasons are more uniform, springwood and summerwood are often indistinguishable, so the wood appears to have no annual rings at all.

Since the annual growth rings form the grain in planks or boards after they are sawn, the contrast between springwood and summerwood is an important means of identifying different species of wood. A species of wood with distinctive growth rings has a pronounced or obvious grain, whereas a species with little contrast in the growth rings shows little grain, or obscure grain.

NOTES

Fast-growing softwoods such as Douglas fir may have as few as four rings per inch, but slow-growing trees can have more than 100 rings per inch. Structural-quality lumber should have at least six rings per inch and the summerwood rings should be at least a third as thick as the springwood rings.

Trees with a lean will have compression wood on the side of the lean. When the log is milled, these forces will be released and the lumber is likely to warp, twist, or bow. Very tall trees can develop internal cracking known as "wind shake."

Moisture and Drying

Wood will shrink as it dries, and during this process it can also warp. The amount of moisture contained in wood is referred to as its "moisture content." It's expressed as a percentage of the weight of water contained in a piece of wood divided by the oven-dry weight of the wood. Because of this measuring system, wood can have a moisture content of more than 200%.

Wood used for framing should have a moisture content of 15 to 19%. Wood used for finishing should have a moisture content that's between 8% and 11%. There are electronic moisture meters to measure the moisture content in wood. When using a moisture meter, corrections must be made for species type and temperature.

Water is found in two places in wood: within the cell cavity and in the fibres of cell walls (Figure 6). Water in the cell cavity is called "free water"; water in the fibres of cell walls is called "bound water" (absorbed water).

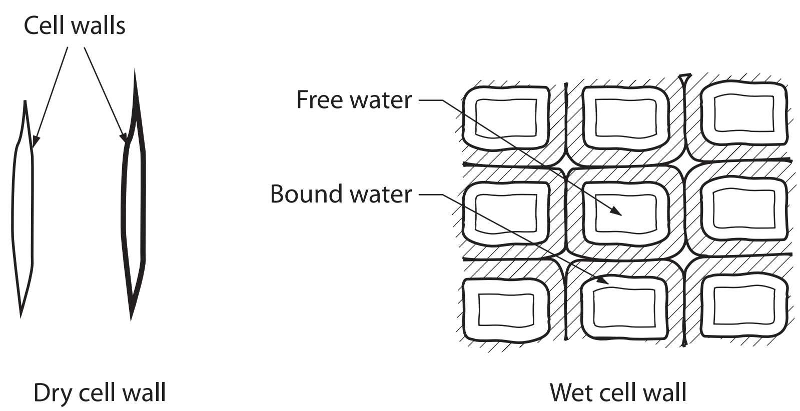


Figure 6 – Moisture exists in wood as either free water or bound water

NOTES

When wood dries, it gives up its free water before its bound water. The reverse occurs when a dry piece of wood is exposed to moisture. The cell walls absorb moisture until they become totally saturated and can hold no more. This state is known as the "fibre saturation point" or FSP. Once FSP is reached, additional moisture accumulates in the cell cavities as free water. For most commercial woods, FSP is reached at moisture content of 25 to 30%.

When wood dries, shrinkage does not take place until all the free water is gone from the cells. Shrinkage occurs as water is removed from the cell walls. There is very little shrinkage along the length of wood. Wood tends to shrink or expand across its width and thickness, with the greatest shrinkage taking place along the circumference of the annual rings, and less shrinkage along parts perpendicular to the annual rings (Figure 7).

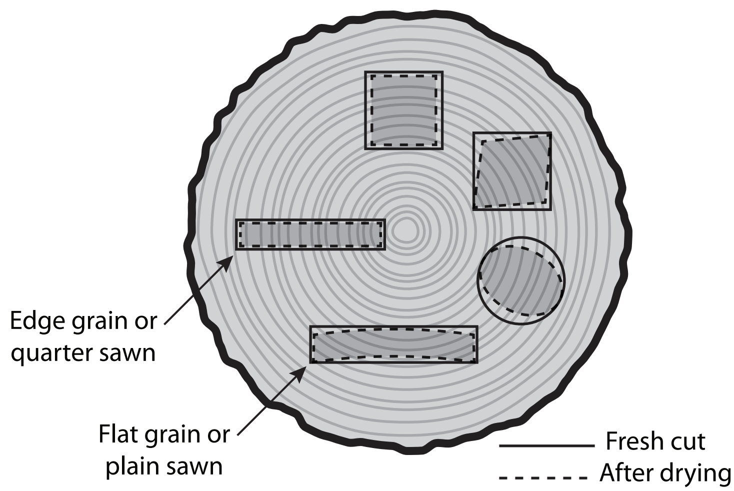


Figure 7 – Shrinkage of wood across the grain

Flat-grain or plain-sawn boards are cut along the tangential face and tend to cup away from the centre as they lose moisture. If they gain moisture, they cup in the opposite direction (Figure 8).

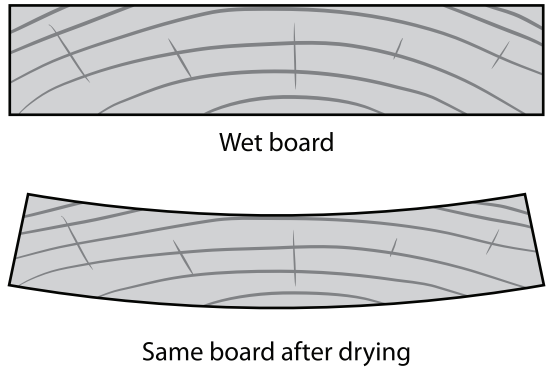


Figure 8 – Flat-grain board

NOTES

Edge grain lumber does not suffer as much distortion when exposed to changes in moisture content. Although there will be a slight reduction in board thickness and width, there will be little or no warping, as shown in Figure 9.

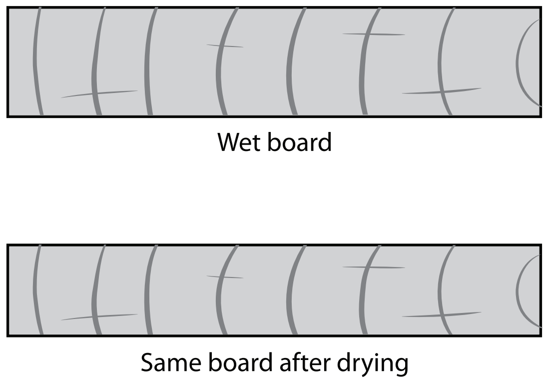


Figure 9 – Edge-grain board

Identify Softwood Species and Characteristics

For commercial purposes, certain species of wood are combined into a single grouping. This is done because some species, once in lumber form, cannot be easily distinguished from others by a visual inspection. Also, grouping simplifies the task of identifying a large number of species.

The strength data for the group is determined by the weakest species in the group. Some groupings contain different species of wood with similar strength ratings, while others may be grouped together because of regional growth.

The common species groups listed in the *British Columbia Building Code* structural tables are Douglas fir-larch, hem-fir, spruce-pine-fir, and northern species. Northern species includes all species not listed in the other groups that are covered by National Lumber Grades Authority (NLGA) Standard Grading Rules and includes western red cedar. The following table describes these species.

NOTES

Species	Weight, Strength, Density, etc.	Characteristics
Douglas fir	• Moderately heavy • Very stiff • Very strong • Very hard	There is a pronounced difference between the heartwood, which is orange red to red or sometimes yellowish, and the sapwood, which is much lighter in colour to a pale brown. Its resin canals are more abundant and more readily detectable than in the western larch. It has a distinctive odour.
Western larch	• Very heavy (the heaviest of all softwoods) • Very stiff • Very strong • Very hard	The heartwood is reddish brown in colour; the sapwood is much lighter and has a yellowish-brown shade. Its resin canals are smaller and harder to see. It does not have a distinctive odour.
Western hemlock (Pacific coast hemlock)	• Medium weight • Moderately stiff • High strength • Moderately hard	Colour ranges from pale yellow-brown to white, sometimes with a pinkish to reddish-brown tinge. It is normally free from resin, an important factor for certain uses. It has no distinctive odour.
Sitka spruce	• Light in weight • Moderately stiff • Moderately strong • Medium soft hardness	The colour is from creamy-white to a light pinkish tinge. There is little difference between the heartwood and sapwood, but a considerable difference between the springwood and summerwood. The wood is straight-grained and strong for its weight-to-strength ratio. An ideal wood for ladders and scaffolding. After seasoning there is no taste or odour.
Spruce Pine Balsam fir Alpine fir	• Moderate weight • Moderately stiff • Moderately strong • Medium soft hardness	Quite light in colour, and except for some pines, have little to no odour or taste after being seasoned.
Western red cedar	• Light weight (lightest of all softwoods) • Moderately stiff • Weak strength • Fairly soft	Colour ranges from a pinkish red to a deep, warm brown. Sapwood has a light yellow tinge. Wood is very straight-grained and splits readily and uniformly. It has a distinct odour.

Now complete Self Test 7 and check your answers.

Self Test 7

1. List the three main parts of a tree.

____

____

____

2. Identify each of the structures shown in Figure 1.

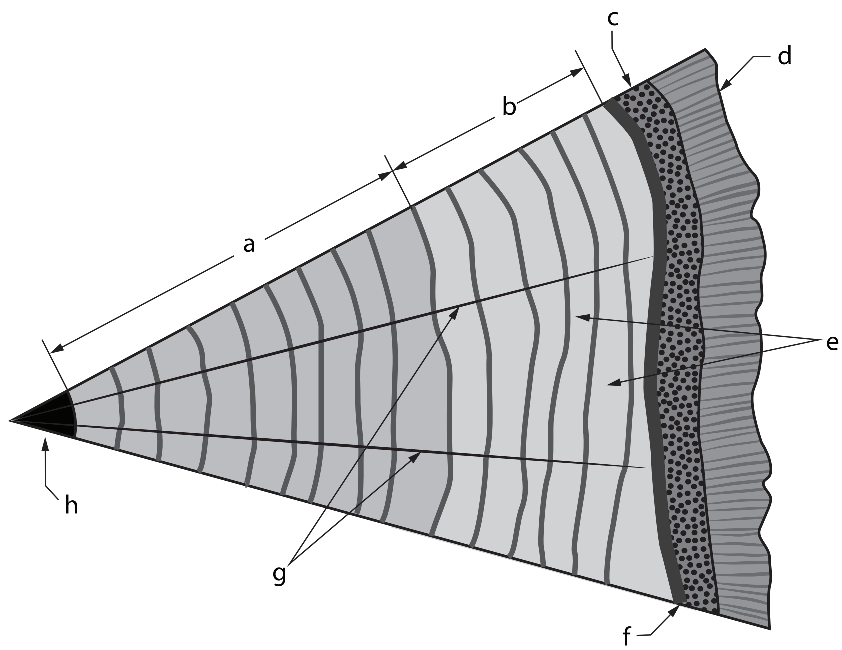


Figure 1

a. _______________

b. _______________

c. _______________

d. _______________

e. _______________

f. _______________

g. _______________

h. _______________

3. Match each of the eight wood structures identified in Question 2 to one of the descriptions below:

   i. This structure is an extremely thin region of living cells, which is responsible for the formation of the millions of new cells produced by a tree each year. The cells produced by this structure form other structures, which make up the bulk of the tree.

   ____

   ii. This region of the tree consists of light-coloured, commercially valuable wood. Its function is to conduct sap upward from the roots to the crown of the tree.

   ____

   iii. Consisting of dark-coloured, structurally weak material, this structure is located at the centre of the tree. First wood growth takes place around it.

   ____

   iv. These long, narrow structures appear as fine lines on the surface of a cross section of a tree trunk or branch. Their purpose is to conduct food and moisture laterally across the trunk or branches.

   ____

   v. This corky material is composed entirely of dead cells. Its function is to protect the tree from pests, disease, and damage.

   ____

   vi. This part of tree wood is darker than other wood structures. Composed of dead cells with natural tannins and resins, it’s more durable and less susceptible to decay than other wood structures. Its main function is give the tree structural support.

   ____

   vii. This region of the tree transports sugars from leaves down to mix with water and nutrients from the roots.

   ____

viii. These structures consist of concentric circles or rings, which are visible on a cross-sectional cut of a tree trunk or branch. They can be used to determine the age of a tree and eventually they form the wood grain pattern when a log is sawn into boards.

____

4. Tropical woods tend to have an obscure grain, while most woods native to North America tend to have an obvious grain.
   a. true
   b. false

5. What is water in a cell wall called?
   a. bound water
   b. free water

6. At what stage of drying does wood begin to shrink?

____

____

7. Where does the greatest shrinkage take place in a piece of wood?

____

____

8. A cup is formed when a ___________ -grain board dries out.

9. Which is the heaviest species of softwood?

____

10. Which is the lightest species of softwood?

____

11. Which three species of wood are considered to be the strongest of the softwoods?

12. Which species of wood is considered to be free from resins?

13. Which species of wood is best suited for manufacturing ladders?

14. Name four species of wood that have very little or no taste or odour.

15. Which species of wood has a deep, warm brown colour?

LEARNING TASK 8

Select Wood with Common Defects for Framing

Notes

Some wood defects occur naturally; others are caused by the manufacturing and handling of the lumber. The following are common defects:

- warp
- compression wood
- mechanical defects
- split, check, or shake
- knots
- wane
- pitch, streaks, and stained wood
- decay
- insect damage
- manufacturing imperfections

Warp

Warp is any deviation from a true or plane surface and includes cup, bow, twist, diamonding, crook, kink, or any combination of these. Incorrect seasoning can cause warp, or it can occur naturally in lumber. When a tree is growing, parts of its trunk may be under various stresses, but these stresses are in equilibrium. However, when the log is cut the stresses act in different ways to cause warp. Figure 1 shows the various forms of warp.

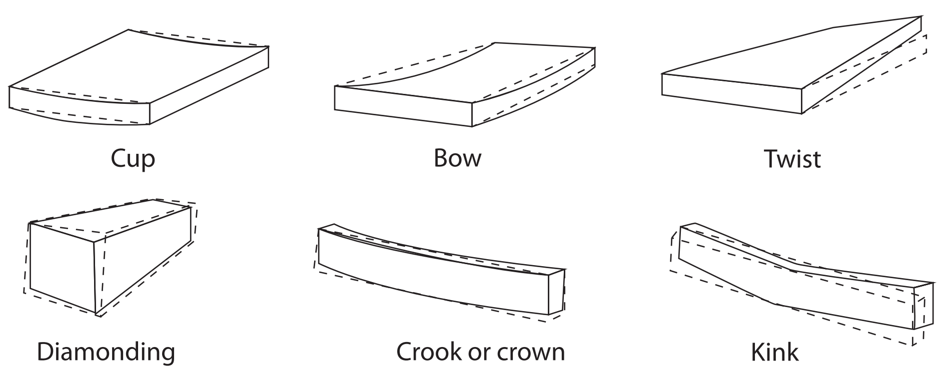


Figure 1 – Types of warp

Cup

A cup is a deviation from a straight line drawn from one edge of a piece to the other across the board's face. It's measured at the point where the defect's distance from the straight line is greatest.

NOTES

Bow
A bow is a lengthwise deviation from a straight line drawn from one end of a piece to the other. It's measured at the point where the defect's distance from the straight line is greatest.

Twist
A twist is a deviation that occurs flat-wise, or is a combination of flat-wise and edgewise deviations which take the form of a curl or spiral. The amount of twist is the distance that an edge of the piece at one end is raised above a flat surface when both edges of the opposite end rest snugly on the flat surface.

Diamonding
Diamonding is a change in the shape of a timber and is due to unequal shrinkage. The sides of the timber are no longer square to each other.

Crook
A crook (crown) is a deviation that occurs edgewise from a straight line drawn from one end of a piece to the other. It's measured at the point where the defect's distance from the straight line is greatest. A slight crown up is desired for the installation of joists to counteract live and dead loads.

Kink
A kink is a deviation of a straight line and is caused by a large knot in the length of wood.

Compression Wood
Compression wood is abnormal wood that forms on the underside of leaning and/or crooked coniferous trees. It's characterized by hardness, brittleness, and a relatively lifeless appearance. Its colour is easily distinguished from that of normal wood.

Lumber with this defect is not permitted if any of the following conditions apply:

- The defect can be readily seen.
- It rates potentially damaging in the stress grades.
- It is specifically listed as unacceptable.

NOTES

Mechanical Defects

Mechanical defects in lumber occur after a tree has been felled. Most of the defects occur during the manufacturing process or handling process in the mill or lumber yard. Improper seasoning techniques, improper handling, and improper storage are common causes.

Warp generally occurs during the drying process. Normally, boards near the bottom of a stack are held flat by the weight of boards above them and, in most cases, warping is prevented. If, however, the top boards in the pile are not weighted, warping may take place.

Split, Check, or Shake

A ***split*** is a separation of wood which happens when wood cells tear apart.

A ***check*** is a separation of the wood, which normally occurs across or through the rings of annual growth. It's usually the result of seasoning when there is uneven shrinkage.

A ***shake*** is a lengthwise separation of wood. Usually it occurs between or through the rings of annual growth. Shake can be caused in standing trees when there is a large amount of movement caused by wind.

The pith shake (heart shake, star shake, or heart check) extends through the growth rings from or through the pith towards the surface of a piece. It can be distinguished from a season check by the fact that the greatest width of a season check in a pith-centred piece is farthest from the pith (Figure 2).

A ring shake or cup shake occurs between the growth rings and partially or wholly encircles the pith (Figure 3).

Figure 2 – Checks along the rays are called "pith shakes," "heart shakes," and "star shakes"

Figure 3 – Shakes formed along the annual rings have a characteristic ring or cup shape

NOTES

Knots

Knots are formed by the natural growth of branches from a tree's main stem. They're classified by their shape and size and by the firmness with which they're held in a piece of wood.

A knot bonded to wood is called a "sound" or "live knot" because it's formed from a live branch. It starts out as a bud on the side of a tree trunk, and as it develops, successive layers of wood cover it. As a result, both trunk and branch increase in girth at roughly the same rate and the bark is gradually stretched and expanded to form a continuous protective layer over the whole tree. As long as the branch remains alive, its outer growth rings remain fused to the adjoining trunk wood. Even after the tree is cut into planks, the knot will remain in place.

Figure 4 shows the natural formation of knots in wood. In Figure 4a, branches form on the sides of the leading shoot. In 4b, both branches and trunk increase in girth as the tree grows. In Figure 4c, cross section of branches appear as knots in a squared block. In Figure 4d, cutting parallel to the branch forms the spike or splayed shape.

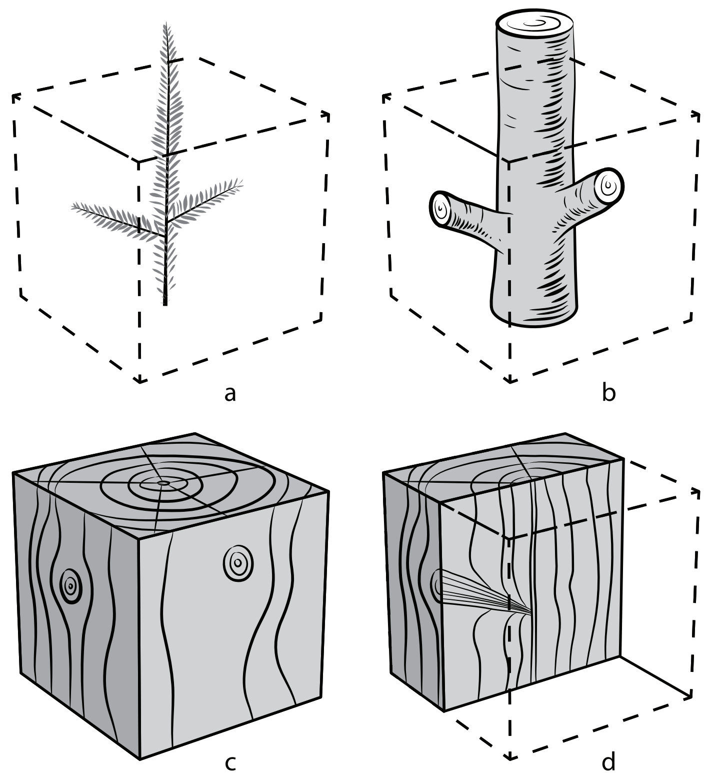


Figure 4 – Natural formation of knots in wood

NOTES

A dead knot (also called a “black knot”) forms after a branch dies. This often happens in lower branches that have been deprived of light by dense foliage above them. Without light, food to the branches diminishes, and the branches die and eventually drop off. The trunk, on the other hand, continues to grow and with each year’s layer of new growth, it gradually envelops the stump of the dead branch. Figure 5 shows the formation of a dead knot.

Figure 5a shows a section of a tree with a branch broken off. In 5b, the trunk grows over branch and the surrounding bark. In 5c, a plank cut along the dotted line includes a section of the embedded branch. 5d is a section of the plank showing the knot falling out, while 5e is the face of the plank showing a ring of bark around the knot.

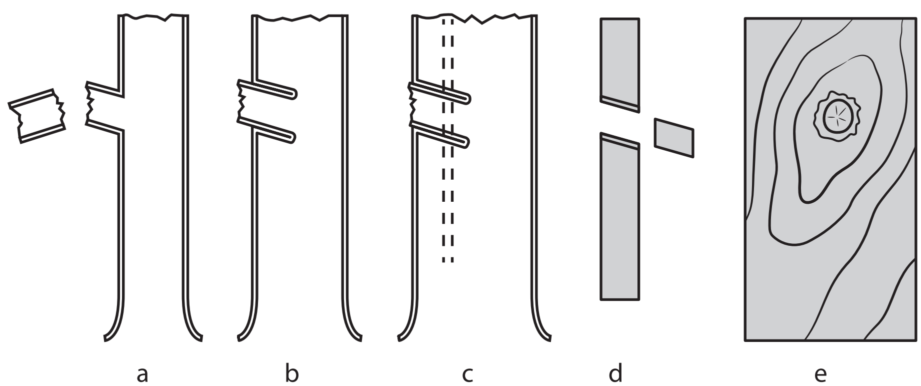


Figure 5 – Formation of a dead knot

When the branch is dead, it no longer produces new layers of wood with each growing season, and the wood of the branch is not bonded with the trunk wood as is the case with a sound knot. Instead, the bark surrounding the dead wood forms a dividing line between the branch and the wood. Figure 6 shows the inter-grown or live portion of a knot and the encased or dead portion.

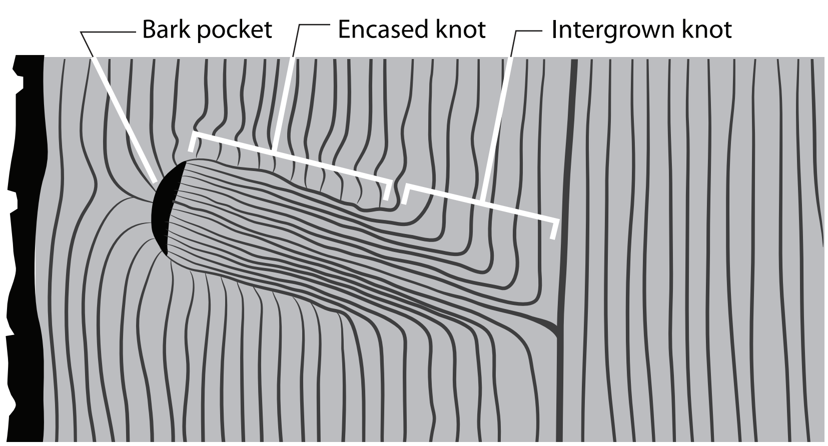


Figure 6 – The inter-grown portion of knot is bonded to the trunk wood while the encased knot is separated by a layer of bark

NOTES

Dead knots are usually classified according to the tightness with which the adjoining wood holds them. A tight knot is one which, though separated from the adjoining wood, is held firmly by the wood and remains tightly in position even after the planks are cut. However, a tight knot cannot be depended on to remain in place and may work loose later.

A loose knot develops when the knot or surrounding bark shrinks and allows sufficient play for some movement of the knot, which may cause the knot to drop out of the plank. This leaves a knothole behind.

The size and shape of knots are determined by the method of cutting logs into boards. Plain-sawn cutting usually produces round or oval knots. Spiked or splayed knots result when logs are quarter-sawn and cut along the radial face.

Pin knots are small knots less than 6 mm in diameter. They're found close to the centre of the log (Figure 7).

Loose knot

Tight knot

Spike knot

Figure 7 – Classification of knots by size and shape

Knots tend to be more resinous than the surrounding wood and have a greater proportion of thick-walled cells. As a result, knots are usually darker, harder, and denser than trunk wood.

Knots are usually considered defects for the following reasons:

- In most cases, knots are considered blemishes, which spoil the appearance of wood.
- Knots deflect the grain of the wood and weaken the strength of the board.

Notes

- Knots provide an inlet for wood-destroying fungi. Although sound knots will remain in place, they may crack and provide an opening for fungi.
- Because knots are harder and denser than the surrounding wood, they make tooling operations (such as planing) more difficult.

For certain applications knots may be considered an asset. For example, knotty pine wall panelling contains knots that lend a decorative quality to the final product.

Wane

Wane is missing wood on the edge or corner of a board. It is often caused by milling a piece of lumber from the edge of the log. It may or may not have bark. It can also occur due to other causes.

Figure 8 – Piece of lumber with wane

Pitch, Streaks, and Stained Wood

Pitch is the accumulation of resinous material. It usually collects when wood in the tree is damaged by wind or lightning.

Pitch streak is a well-defined accumulation of pitch in the wood cells, in a more or less regular streak. It should not be confused with dark grain.

Stained heartwood and firm, red, heart-stained heartwood, or firm red heart, is a marked variation from the natural colour. The colour ranges from pink to brown and should not be confused with natural red heartwood. Stains are usually irregular patches. In grades where they are permitted, they have no more effect on the intended use of the pieces than other characteristics permitted in the grade. Stained sapwood similarly has no effect on the intended use, but it affects appearance in varying degrees.

NOTES

Decay

Decayed wood is known by a great many names, such as heart rot, pocket rot, brown rot, white rot, and dry rot. Each indicates the nature or the location of the decay. Regardless of the name, all decay results from the invasion of a single class of plants called "fungi." Once the moisture content in the wood is below 20%, no further rot occurs, but the wood remains damaged.

"Fungi" is a general term given to plants that produce no food of their own but feed from the living tissues or residues of other plants and animals. Probably the best-known fungus is the common mushroom.

Like all fungi, the fungus varieties that attack wood consist of two parts called "fruiting bodies" and "mycelium." The fruiting body is the part visible above the surface of the wood.

The mycelium is a mass of tiny, thread-like structures which penetrate the tree and draw nourishment from the depths of the wood. Each of the threads making up the mycelium is so small that it can thrust through the centre of a softwood cell, just as a sewing thread is pushed through a needle.

The damage fungi inflict on wood depends on the type that attacks it. There are two basic types:

- sap-stain fungus
- rot fungus

Sap-stain Fungus

The sap-stain fungus causes wood to turn blue, but it has no effect on the structural strength because it feeds on the contents of the wood cells without damaging the cell walls. The black root hairs of the sap-stain fungus are so slender that they can squeeze through the pit openings of softwood cells, leaving the cell walls intact. Pine, for instance, is very sensitive to sap-stain fungi, so care must be taken to prevent fungal attack.

Rot Fungus

The rot fungus has the opposite effect—it feeds on both the contents of the cells and the cell walls themselves. In the course of passing from one cell to the next, it breaks large holes in the cell walls, and the holes cause the wood to deteriorate. The effects of rot and sap-stain fungi are illustrated in Figure 10.

NOTES

Figure 9 – Effect of sap-stain and rot fungi on softwood cells

Rot fungi are the more serious of the two types. While sap-stain fungi can usually be controlled by thoroughly drying the wood, timber infected with rot fungi must be discarded or have the infected portions removed.

Rot fungi takes one of three forms:

- brown rot
- white rot
- dry rot

Brown Rot

Brown rot attacks the cellulose material that makes up the walls of wood cells. It eventually reduces the affected wood to a brittle, brownish material. Most types of brown rot do not persist after the wood has been dried.

White Rot

White rot attacks both the cellulose that makes up the cell walls and the lignin that binds the cells. White rot is also called "white speck," which is an initial stage of white rot. Infection shows itself as a soft, pulpy mass of whitish material, which has no structural strength. Like most forms of brown rot, white rot develops before a tree is felled and does not persist after drying. It must be removed from finished lumber by sawing out infected portions.

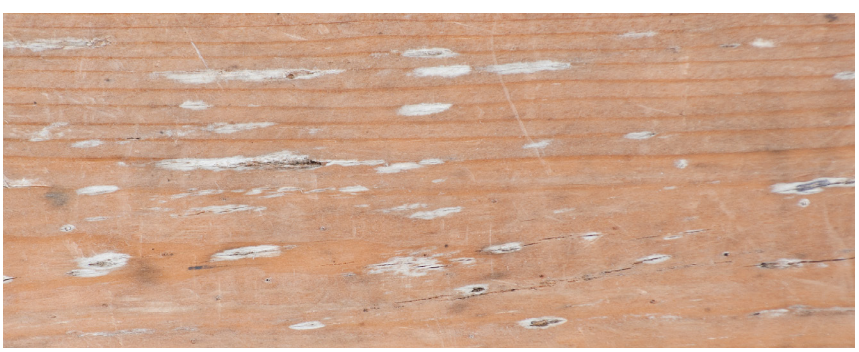


Figure 10 – White rot

NOTES

Dry Rot

Dry rot infects trees after they are felled and can continue to thrive after the lumber-drying process. Dry rot often turns up after wood is put into service and is expensive to remove. Despite the name, there is nothing dry about the places where this rot thrives. It appears in poorly ventilated areas such as cavities beneath wood floors. It also occurs in wood surfaces that are in contact with damp walls. The name "dry rot" comes from the condition to which infected wood is reduced: the wood breaks into dry brown cubes, which crumble to a fine dust under finger pressure.

Decay starts when all three of the following conditions are present:

- lack of ventilation
- high moisture content
- heat (warmth above 15°C)

When one of the above conditions is eliminated, decay is stopped—but nothing cures it. There are, however, measures that prevent decay:

- ensure that framing lumber has been dried to a moisture content of 19% or less
- ensure that wood placed in service is adequately ventilated
- protect wood from moisture sources
- treat wood to prevent fungus attack when located in high-moisture locations

Insect Damage

An infestation of insects can destroy the wood in a structure. Some insects that damage wood are:

- carpenter ant
- western subterranean termite
- Pacific dampwood termite
- powder-post beetle
- teredo worm
- mountain pine beetle

NOTES

Carpenter Ant

The carpenter ant may nest inside wood, in hollow walls, under insulation, or in other cavities. It does not eat wood but rather ejects sawdust, as well as styrofoam and insulation, when it hollows out an area for its nest.

Figure 11 – Carpenter ant damage

A colony and any associated satellite colonies will have only one queen ant. Seventy-five percent of all colonies will have one or more satellite colonies (generally in dry wood). A nest is established when a queen enters a structure and begins laying eggs or when a whole colony moves in, usually after being disturbed. Damp wood or damp areas are preferred.

Signs of a colony living inside a building are:

- sightings of worker ants, 6–12 mm in size
- piles of sawdust
- rustling sounds in walls, floor, or ceiling
- sightings of workers inside the house in winter or spring when it's too cold for them to be outside
- ant trails to and from the house

The ants live in the structure but must leave to obtain food. During the fall and winter, they become dormant and no activity is observed. Workers may be seen inside early in the year, but they become less visible later in the season when they go outside to obtain food.

Winged males and females leave the nest in the spring. They search for mates and establish new colonies.

A qualified pest control manager can provide effective control of carpenter ants. Improper treatment can result in scattering nests, which makes control difficult.

NOTES

Western Subterranean Termite

The western subterranean termite feeds on wood and consequently can be very destructive to wooden structures. Fortunately it's still fairly rare in British Columbia but is becoming more common.

Figure 12 – Subterranean termite

Subterranean termites live in wood in contact with the soil but will travel inside specially-constructed mud tubes to feed on wood above the soil. Most of their damage is confined to wood in basements and at ground level.

The termites enter buildings through cracks and holes in concrete or where wood is in contact with the soil. A small crack in concrete around drain pipes or between a concrete slab and the foundation is all the space these termites need to gain access to a building.

These termites are sometimes first detected by the presence of their mud tubes, or when obvious structural weakening occurs, or when large numbers of winged termites leave their colony in search of mates. The winged termites are about 10 mm long and have black bodies and long, pale wings. They usually leave their colonies in late summer.

Pest control professionals are needed to control the subterranean termite. Control requires blocking the termite's access to its food source by physical and chemical means.

Pacific Dampwood Termite

The Pacific dampwood termite attacks wood with a high moisture content. It produces long, flat tunnels in wood. In some cases, the entire inside of infested wood is eaten, leaving only a thin outer shell of wood. Because the termite leaves very little external evidence of its presence, close inspection is usually required to detect an infestation.

NOTES

Male and female dampwood termites have brown bodies with long, translucent, brown wings. Their overall length is about 25 mm. The male and female usually leave the colony in large numbers during warm evenings in late summer. The worker termite is creamy white in colour and never leaves the wood in which it lives.

Control of the Pacific dampwood termite is usually a job for an experienced building contractor. All termite-damaged wood must be removed and all other repairs made, to ensure that all sources of moisture are eliminated. Spraying cannot solve this problem.

Powder-post Beetle

The powder-post beetle bores small round holes, 2–3 mm in diameter, throughout the wood. These are the exit holes of the adult beetle. Inside the wood are tunnels filled with fine sawdust and excrement. Fine powder may be observed coming out of the holes or in piles under the holes.

Figure 13 – Powder-post beetle damage

The adult beetle emerges from the wood between April and July. Eggs are laid in midsummer in cracks and holes in exposed wood. Grubs hatch from the eggs and enter the wood. Its feeding produces fine sawdust in the tunnels. One or more years after entry, the grub becomes an adult beetle.

The powder-post beetle commonly attacks structures under buildings. Sapwood with high moisture content in shaded areas is especially susceptible to attack. Structural damage to wood is caused by continual infestation of the wood. Serious weakening may occur even though the outside appearance is normal (other than the exit holes).

To control a powder-post beetle infestation, perform all work recommended by pest control management specialists. Ensure that all wood in the house is dry and, if necessary, treat it with an appropriate insecticide.

NOTES

Teredo Worm

The Teredo worm is a destructive pest of submerged timber. Softwood can become riddled with tunnels within months of being in salt water.

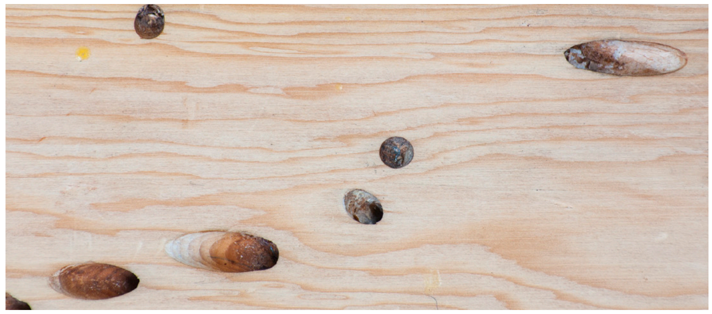


Figure 14 – Teredo worm tunnel damage

Mountain Pine Beetle

The mountain pine beetle, is a species of bark beetle native to the forests of western North America from Mexico to central British Columbia. It has always been part of the ecosystem of the western forest, but several years of unusually hot, dry summers, mild winters and large areas of mature forest, have led to an epidemic.

In western North America, the outbreak of the mountain pine beetle peaked in 2005 and has destroyed wide areas of lodgepole pine forest, including millions of acres in British Columbia.

The beetle lays eggs under the bark and introduces blue stain fungus into the tree which blocks the flow of sap. The combination of the feeding larvae and the fungus girdles the tree and kills it in a couple of years. Once the tee dies, the beetles leave the tree. Blue stain is the tell-tale sign that the tree has been infected.

If the trees are harvested within 8–10 years of dying, the lumber is typically still sound. The wood will be dryer than normal and prone to checks and cracks. The blue stain does not affect the structural properties of the lumber

Manufacturing Imperfections

NOTES

Manufacturing imperfections are blemishes that occur during the manufacturing process. They include the following:

Chipped Grain – Particles of wood are chipped or broken below the line of cut. They're too small to classify as torn grain.

Torn Grain – An irregularity in the surface of a piece, where wood has been torn or broken out by surfacing.

Raised Grain – An unevenness between the springwood and summerwood on the surface of dressed lumber.

Loosened Grain – A grain separation or loosening, without displacement, between springwood and summerwood.

Skip – An area that has not been surfaced cleanly.

Hit and Miss – A series of skips, with surfaced areas in between.

Mismatch – The uneven fit that results when adjoining pieces of worked lumber do not meet tightly at all points of contact, or when the surfaces of adjoining pieces are not in the same plane.

Machine Burn – Darkening of the wood is due to machine knives or rollers becoming overheated when pieces are stopped in the machine.

Machine Bite – A depressed cut by the machine knives at the end of a piece (also known as "planer snipe").

Machine Gouge – A groove cut by the machine below the desired line.

Machine Offset – An abrupt dressing variation in the edge surface, which usually occurs near the end of a piece. It does not reduce the width or change the plane of the wide surface.

Chip Marks – Shallow depressions or indentations on the surface of dressed lumber. They occur during dressing when shavings or chips become embedded in the surface.

Knife Marks – Machine knives on the surface of dressed lumber make these imprints or markings.

Wavy Dressing – Deep depressions that leave uneven surface dressing.

Now complete Self Test 8 and check your answers.

Self Test 8

1. What causes wood decay?

2. Does sap-stain fungi weaken the strength of wood?

3. Name three common types of rot.

4. List three precautions that should be taken to prevent rot.

5. Identify each of the defects or damage shown below.

a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

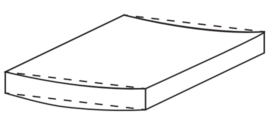
6. Name the three main causes of manufacturing defects in lumber.

____

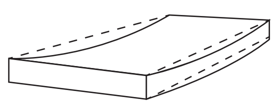
____

____

7. Identify the six types of warp illustrated below.



a. ______________________________



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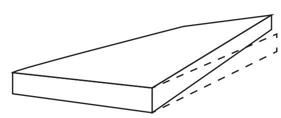
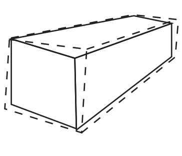
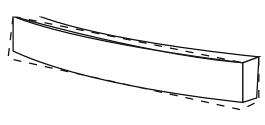


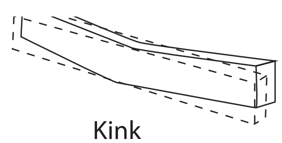
c. ______________________________



d. ______________________________



e. ______________________________



f. ______________________________

8. What causes a board to warp?

9. Which insect leaves piles of sawdust and makes a rustling sound in walls?

10. Which insect travels in specially constructed mud tunnels?

11. Which insect bores small round holes in wood?

12. What type of defect occurs when particles of wood are broken below the line of cut?

13. Describe "machine burn."

14. What causes chip marks?

15. Describe a twist in a piece of lumber.

NOTES

LEARNING TASK 9

Select Standard Sizes and Grades of Framing Lumber

Wood used in construction must be uniform in size and grade. The National Lumber Grades Authority (NLGA) regulates lumber sizes and grades. All lumber used in wood-frame construction must be inspected and approved by NLGA-certified lumber graders.

Dimensions

The nominal dimensions of a piece of wood are its dimensions after rough-cutting. The actual dimensions are the dimensions after it's been surfaced. For example a "2×4" is approximately 2" by 4" when rough, but 1½" by 3½" after it's been dried and surfaced. Lumber is usually referred to by its nominal dimensions.

The actual dimensions vary for wood that's surfaced dry and wood that's surfaced green.

Surfaced Dry

Lumber that's surfaced "dry" is dried before being planed to dimension. Surfaced dry lumber has a moisture content of 19% or less when leaving the mill. However, it can absorb moisture from damp conditions, so it needs to be kept dry when stored to stay within the moisture allowance (19%) for framing lumber.

The actual dimensions of surfaced dry lumber are as follows:

Nominal dimension	Actual dimension
2"	1½"
4"	3½"
6"	5½"
8"	7¼"
10"	9¼"
12"	11¼"

Lumber with a nominal dimension of 2 to 6" has an actual dimension that's ½" smaller. Lumber with a nominal dimension of 8, 10, or 12" is smaller by ¾".

NOTES

Surfaced Green

Lumber that's surfaced "green" has not been kiln-dried before being planed to dimension and has a moisture content over 19%. Surfaced green lumber finishes drying after it's installed in a building.

The actual dimensions of surfaced green lumber are as follows:

Nominal dimension	Actual dimension
2"	1 9⁄16"
4"	3 9⁄16"
6"	5 5⁄8"
8"	7 ½"
10"	9 ½"
12"	11 ½"

The difference between the nominal dimension and the actual dimension is due to the planing operation. Surfaced green lumber with nominal dimensions of 2–4" has an actual dimension 7⁄16" smaller than the nominal dimension. Surfaced green lumber with a nominal dimension of 6" is reduced by 3⁄8", and lumber 8, 10, or 12" wide is reduced by ½". The variation in sizes is in anticipation of future shrinkage—wider boards will have greater shrinkage.

The *Building Code* explicitly states that lumber used for framing must have a moisture content of 19% or less. This is because wood with a moisture content of 20% or more will grow damaging fungi. If the moisture content is kept below 20%, the fungi will not grow and the board will not rot.

Mixing surface dry lumber with surface green lumber for the same framing project can be problematic.

Lumber Sizes

Listed below are the nominal dimensions of standard groups by usage of softwood lumber produced in British Columbia.

Boards

Boards are 1" in thickness by 2, 4, 6, 8, 10, or 12" in width.

Light Framing

Light framing lumber is 2–4" thick by 2–4" wide.

NOTES

Joists and Planks
Joists and planks are 2–4" thick by 6, 8, 10, or 12" wide.

Beams and Stringers
Beams and stringers are 5" or more in thickness and more than 2" greater in width than in thickness.

Posts and Timbers
Posts and timbers are 5" by 5" or greater in cross-sectional dimension. They must not be more than 2" greater in width than in thickness.

Decking
Decking is 2–4" thick by 4–12" wide.

Siding
Siding has its thickness expressed by the dimensions of the butt edge. Siding widths are from 4 – 12".

Grading
Softwood lumber used for construction is graded by two methods:

- visual grading
- machine stress rating

Visual Grading
A lumber grader inspects every board that's sawn and graded. The grader checks for defects and then stamps the board with the appropriate grade stamp. Sample grade stamps are shown in Figure 1. Surfaced green lumber will have "S-GRN" as part of the stamp. Surfaced dry lumber will have "S-DRY" as part of the stamp, with the exception that kiln-dried lumber is allowed to have "KD" instead.

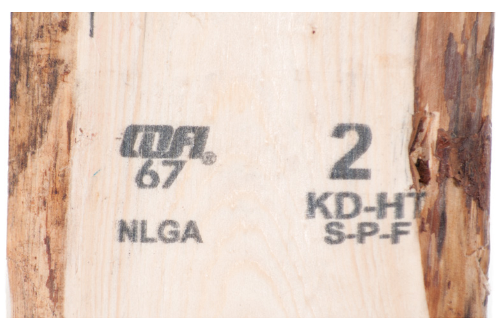


Figure 1 – Grade stamps used on BC softwood lumber

NOTES

Machine Stress Rating

Lumber that's machine stress rated is passed through a device that measures how much the actual piece of lumber will bend or flex under a given load. The piece is then automatically stamped with its strength.

The critical members in engineered wood trusses are made from machine stress rated lumber. This ensures that the wood is strong enough to support the intended loads and stresses.

Grades

The grades given by the visual grading process are based on the lumber's strength after factoring in any defects. The grade of the piece of lumber being graded is rated as a percentage of the strength of a clear, defect-free piece of lumber of the same species.

The "select structural" grade is not readily available and should not be specified when designing building components unless a source is available.

Grades 1 and 2 are often combined under the grade "#2 and Better." Economy grade is only allowed under the *BC Building Code* for wall sheathing not required as a nailing base.

Structural Light Framing

Structural light framing is divided into four grades.

Grade	Abbreviation	Percentage of the strength of a clear defect-free board
Select Structural	(Sel Str)	67%
Number 1	(No. 1)	55%
Number 2	(No. 2)	45%
Number 3	(No. 3)	26%

Light Framing

Light framing is divided into four grades.

Grade	Abbreviation	Percentage of the strength of a clear defect-free board
Construction	(Const)	34%
Standard	(Stand)	19%
Utility	(Util)	9%
Economy	(Econ)	(not strength rated)

Stud

There are two stud sizes: 2×4 and 2×6. There are only two grades for studs.

Grade	Abbreviation	Percentage of the strength of a clear defect-free board
Stud	(Stud)	26%
Economy Stud	(Econ)	(not strength rated)

NOTES

Structural Joists and Planks

Structural joists and planks are divided into four grades.

Grade	Abbreviation	Percentage of the strength of a clear defect-free board
Select Structural	(Sel Str)	65%
Number 1	(No. 1)	55%
Number 2	(No. 2)	45%
Number 3	(No. 3)	26%

The grades listed above are used to describe the framing members that are designed using the tables in the *Building Code*.

Defects

The size and spacing of natural and manufactured defects in lumber determine the grade of the piece. The defects checked for by the lumber grader include the following:

- checks, shakes, splits
- knots, holes
- pitch and pitch streaks
- manufacture faults, including chipped wood, skips, torn grain
- pockets, pitch, bark
- rate of growth
- slope of grain
- stains
- unsound wood
- wane
- warp
- white speck and honeycomb

NOTES

Density

The density of a material is its weight per unit volume. The table below compares the density of various softwood species as compared to other common building products.

Material	Kg/m^3	$Lbs./ft.^3$***	Relative to water**
Douglas Fir*	400 – 480	31 – 50	0.4 – 0.48
Larch*	400 – 460	31 – 35	0.4 – 0.46
Hemlock*	410 – 470	32 – 36	0.41 – 0.47
Spruce*	350 – 390	27 – 30	0.35 – 0.39
Pine*	290 – 400	22 – 31	0.29 – 0.40
Western Red cedar*	310 – 340	24 – 26	0.31 – 0.34
Steel	8000	500	8
Concrete	2400	150	2.4
Water	1000	62	1

* The density of wood will vary depending upon its moisture content. The densities listed are for dry samples.

** If the relative density of a substance is less than 1.0, it will float. If it's more than 1.0, it will sink.

*** $lbs/ft.^3$ is the force due to gravity exerted by one cubic foot of the substance. The weight in pounds is due to the force of gravity, but the mass in kilograms is not.

Now complete Self Test 9 and check your answers.

Self Test 9

1. What is "machine stress rated" lumber?

2. Where is "machine stress rated" lumber used?

3. List the four grades used with lumber classified as "light framing."

4. List the four grades used with lumber classified as "structural joists and planks."

5. What are the actual dimensions of a 2×6 that's surfaced dry?

6. What are the actual dimensions of a 2×8 that's surfaced green?What is the density (in metric units) of western red cedar?

7. What is the density, relative to water, for a hemlock log that sinks to the bottom of a lake?

LEARNING TASK 10

Select Panel Products and Engineered Products

Notes

Panel Products

Panel-type products are made by binding and gluing wood particles, fibres, strands, wafers, veneers, and/or boards together to form engineered products. Many are used for sheathing walls, floors, and roofs. There are several basic types of panel products, including:

- plywood
- oriented strand board (OSB)
- waferboard
- composition board

Reconstituted wood panel products are produced by processes involving pressure, adhesives, and binders. They may contain layers made from materials other than wood. Many of these sustainable products are made from waste wood and recycled materials. Common reconstituted wood panel products produced in Canada include OSB, waferboard, particle board, medium density fibreboard (MDF), hardboard, and cellulosic fibreboard (insulating board).

Plywood

Plywood is made from laminations of veneer. Softwood plywood is made from veneers that are peeled from a log. Hardwood plywood is made from veneers that are either peeled or sliced from a log.

Softwood Plywood

Softwood plywood sheathing comes in 4 foot by 8 foot sheets (1.22 m × 2.44 m). The edges of the sheets are left square if used for wall or roof sheathing. Tongue and groove plywood (T&G) is used for floor sheathing (Figure 1).

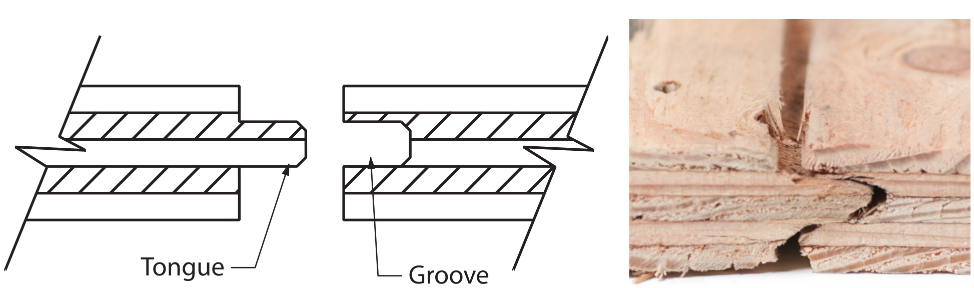


Figure 1 – Tongue and groove plywood

NOTES

Machining the tongue and the groove reduces the width of the sheet. A sheet of T&G plywood covers 47½". This reduction in width must be taken into account when calculating the amount of floor sheathing required.

Canadian manufactured unsanded exterior grade plywood is commonly available in the following thicknesses:

- 5/16"
- 3/8"
- ½"
- 5/8"
- ¾"
- 13/16"
- 7/8"
- 1"
- 1⅛"
- 1¼"

Thicknesses for sanded plywood are about 1/16" (1.5 mm) less.

Plywood Veneer

Plywood sheathing is made from softwood veneers. Logs used to make veneer are cut to just over 8 feet. The logs are turned on a lathe and full 8-foot-wide veneers are peeled off. The veneers are dried and graded.

Softwood plywood normally has 3, 5, 7, or 9 layers of veneer. The outside layers are called face layers and the inside layers make up the core. Sheets of plywood with fewer layers are weaker than sheets made of more layers.

The layers of veneer are laid at right angles to one another (cross-banded)—this strengthens the sheets. The two faces of the sheet have veneers with the grain parallel to the long dimension of the sheet.

The veneers are sprayed with waterproof resin glue and then pressed and heated. The pressure and heat quickly set the glue. After gluing, the sheets are trimmed square to exactly 4 feet by 8 feet.

For maximum strength, plywood sheathing should be installed with the length of the sheet (face grain) across its supports.

Grades

Plywood is available in various grades and is either unsanded or sanded. A sample face grade stamp for unsanded plywood is shown in Figure 2.

Figure 2 – Unsanded plywood face grade stamp

Sanded plywood is often used for finishing work and will have edge grade stamps. Some of the more common Canadian plywood grades are shown in Figure 3:

Grade	Product	Veneer grades			Characteristics	Typical applications
		Face	Inner plies	Back		
Good two sides (G2S)	DFP	A	C	A	Sanded. Best appearance both faces. May contain neat wood patches, inlays, or synthetic patching material.	Furniture, cabinet doors, partitions, shelving, concrete forms, and opaque paint finishes
Sanded	Poplar					
Good one side (G1S)	DFP	A	C	C	Sanded. Best appearance both faces. May contain neat wood patches, inlays, or synthetic patching material.	Where appearance or smooth sanded surface of one face is important. Cabinets, shelving, concrete forms
Select Tight Face (SEL TF)	DFP	B***	C	C	Surface openings shall be filled and may be lightly sanded.	Underlayment and combined subfloor and underlayment. Hoarding. Construction use where sanded material is not required.
Select (SEL)	DFP Aspen Poplar CSP	B	C	C	Surface openings shall be filled and may be lightly sanded.	
Sheathing (SHG)	DFP Aspen Poplar CSP	C	C	C	Unsanded. Face may contain limited size knots, knotholes, and other minor defects.	Roof, wall and floor sheathing. Hoarding, Packaging. Construction use where sanded material is not required.
High Density Overlaid (HDO)	DFP Aspen Poplar CSP	B***	C	B***	Smooth, resin-fibre overlaid surface. Best paint base.	Siding, soffits, panelling, built-in fitments, signs, any use requiring a superior sanded surface.
Medium Density Overlaid (MDO) MDO 1 Side	DFP Aspen Poplar CSP	C***	C	C	Smooth, resin-fibre overlaid surface. Best paint base.	Siding, soffits, panelling, built-in fitments, signs, any use requiring a superior paint surface.
MDO 2 Sides	DFP Aspen Poplar CSP	C***	C	C***		

Figure 3 – Plywood grades

NOTES

Oriented Strand Board

Oriented strand board (OSB) is the most common type of sheathing used in framing, primarily because it's less expensive than plywood and is more uniform in strength. OSB comes in 4×8 sheets and is normally available in thicknesses from 7⁄16" to ¾".

OSB is manufactured from various wood species, including aspen, poplar, and other softwood and hardwood logs. The sheets are made in layers of wood strands and wafers mixed with glue. For the outside layers, the long dimension of the strands is oriented with the long dimension of the finished sheet. Like plywood, inside layers are cross-oriented to the outside layers.

The sheets are manufactured as one huge sheet just over 12 feet by 24 feet. Several sheets are made at the same time. They are made one on top of the other with spacers between. As with plywood, they're pressed and heated to set the glue. A 15 cm (6") thick sheet will compress to 15 mm (⅝").

The large sheets can then be cut into standard 4×8 sheets as well as other sizes used in construction. Rim joists for engineered floors are 12' long and are cut from these large sheets.

Most OSB has painted edges for added protection against moisture.

OSB Grades

The *BC Building Code* has different requirements for OSB based on the grade. Two sheathing grades are recognized:

- OSB, 0-1
- OSB, 0-2

Of the two, OSB, 0-2 is treated as equivalent to plywood, and the less strong OSB, 0-1 is equivalent to waferboard.

Tongue and Groove OSB

OSB can be used as floor sheathing. The edges of this product are primed with paint and drainage holes are spaced along the tongue. This allows the floor to drain during any wet weather before the roof is complete.

Unlike T&G plywood, OSB floor sheathing will cover a full 4-foot width. This creates less waste because most buildings are built to even foot widths.

NOTES

Waferboard
Waferboard looks similar to OSB and is commonly referred to as "Aspenite." Waferboard may be used for floor, wall, and roof sheathing under the *BC Building Code*, but is not as strong as OSB, 0-2. The wafer size is slightly smaller than that for OSB and the wafers are randomly orientated.

Composition Board
There are many types of composition board products, including particleboard, medium density fibreboard, and hardboard. Each uses a specific process and has specific end uses. Unlike plywood and OSB, most composition panels are not suited for any uses other than the specific one for which they were designed. Most are made using wood fibres and/or particles.

Particleboard
Particleboard (chip board) is a composition board made from wood chips, shavings, and sawdust. It's pressed together with a resin binder to form sheets. It's one of the weakest composition boards.

Medium Density Fibreboard
One of the most common composition panel products is medium density fibreboard (MDF). Wood fibre is mixed with wax and resin, then formed into panels under high pressure and temperature. It's stronger and denser than particleboard. Many interior mouldings are also made using MDF.

Hardboard
Hardboard is denser than MDF. It's made from exploded wood fibres that are glued together under very high pressure. Hardboard is often used for clipboards, pegboards, and drawer bottoms. It can also be used as concrete form liners.

Storage and Health
Protect stacks of panel products intended for sheathing from moisture with a tarp or other means. Ensure they're properly supported so they remain true and flat. Take care to protect T&G edges.

Since panel products contain glues, chemicals, and recycled material, dust masks or respirators should be worn when cutting these products.

NOTES

Engineered Structural Products

Cross Laminated Timbers

CLTs are engineered panels made by laminating multiple layers of lumber cross-wise to each other, similar to veneers in plywood. This product is often used as an architectural feature.

Glue Laminated Timbers

"Glulams" are boards (often 2×4 or 2×6) laid on flat and glued together to form a beam or column. They can be produced in curved shapes, offering design flexibility. The *BC Building Code* includes span tables in *Part 9* for glue laminated beams and lintels.

Laminated Veneer Lumber

Laminated veneer lumber (LVL) looks like plywood beams, except all the plies have the grain running in the same direction. Made of multiple layers of thin veneer, this lumber is very strong and stable and can span farther than sawn timbers. LVLs can be used for rafters, headers, beams, joists, rim boards, studs, and columns.

Parallel Strand Lumber

Parallel strand lumber (PSL) is similar to LVL, except instead of full sheets of veneer, strands of veneer are laid in parallel formation and glued together. It has the same uses as LVL.

Structural Insulated Panels

Structural insulated panels (SIP) consist of inside and outside panels with rigid insulation between. The panels are often plywood or OSB. Panels can be splined together to create walls, floors, and roofs. They were originally called "stress skinned panels."

NOTES

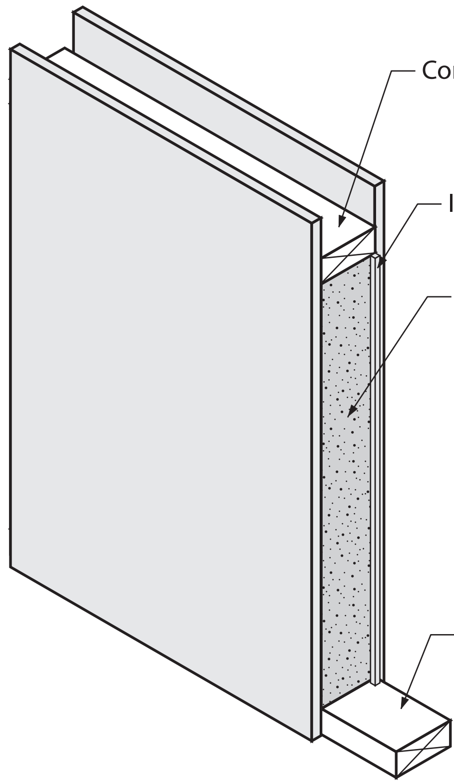


Figure 4 – Structural insulated panel

Now complete Self Test 10 and check your answers.

Self Test 10

1. List two basic types of sheathing panels.

2. Describe cross-banding.

3. What is the coverage in width for T&G plywood floor sheathing?

4. Why is it easy to make a 4' × 12' sheet of OSB but difficult to make it from plywood?

5. What two features do T&G OSB sheets have to help them resist water damage?

6. What grade plywood is used for sheathing? Is it sanded?

NOTES

LEARNING TASK 11

Calculate Quantities and Costs of Framing Lumber

Framing lumber is sold by the piece, the lineal foot, or per thousand board measure. The cubic metre is the quantity used to measure logs sold to a sawmill.

Discounts and Taxes

When calculating costs, discounts and taxes must be considered. The discounts or taxes are expressed as a percentage of the cost.

Percentage is a ratio of the part to the whole. 100% is the whole. 50% of something is half of it. The term “percent” means “per” 100. So 50 percent means 50 divided by 100 or $^{50}/_{100} = 0.5$.

Dividing a percentage by 100 gives the equivalent decimal fraction.

Discounts

Most contractors who maintain an account at a building supply company receive discounts based on the volume of business they have with that supplier. Even without an account, when buying lumber, the supplier will often offer a discount if large amounts are purchased. The discount is taken off the list price. To calculate a discounted price, subtract the percent from 100% and multiply it by the gross cost.

Example

A 12% discount on a list price of \$126.50 results in a net cost of:

$$\text{Net Cost} = \frac{100-12}{100} \times \$126.50 = \frac{88}{100} \times \$126.50 = 0.88 \times \$126.50 = \$111.32$$

Taxes

Taxes are paid when building materials are purchased. The tax is added to the discounted price, or if there is no discount, to the list price. For 7% PST with a list price of \$626.50, the cost including the tax is:

$$\text{Cost Including Tax} = \frac{100+7}{100} \times \$626.50 = \frac{107}{100} \times \$626.50 = 1.07 \times \$626.50 = \$670.36$$

If multiple taxes are applied (such as PST and GST) both taxes are applied separately to the same subtotal price.

NOTES

Waste Factors

If working carefully, there should be little waste, but due to defects in materials, the shape of the building, and the standard sizes of the materials, some waste will occur.

The amount of waste will vary greatly. Allowing for too much waste can overprice your bid, but allowing for too little waste can cut into your profit or even bankrupt a company. Furthermore, if not enough materials are purchased, extra finishing materials must be ordered. This will cause delays in the schedule and the additional material may be from a different dye-lot and not match the original material.

When calculating framing materials, an extra 5 to 7% is typically added for waste.

Example

If 63 pieces of 2×10 are needed and a 5% waste factor is allowed for, the number to order is:

$$\text{Number to Order} = \frac{100+5}{100} \times 63 = \frac{105}{100} \times 63 = 1.05 \times 63 = 66.15 \text{ pieces} = 66 \text{ pieces}$$

Determining waste factors takes time. Keep accurate records of materials ordered and compare them to the original estimates. With experience, the accuracy of waste factors can be estimated more precisely.

Sold by the Piece

All framing lumber can be sold by the piece. Pricing by the piece is very common in most lumberyards.

Lengths

Standard lengths of S4S framing lumber are available in 2-foot increments from 8 feet to 18 feet. Longer lengths are available but are not common.

Rough lumber is available in random lengths. Rough cedar boards are often used for a board and batten exterior finish. These boards may be any length, as the boards are not end-trimmed.

Calculations

A table is usually used when calculating the costs of lumber sold by the piece (Figure 1).

Item	Number of pieces	Cost per piece	Gross cost	Discount	Net cost
8' – 2×4	156	$3.50	$546.00	12%	$480.48
12' – 2×4	46	$4.40	$202.40	12%	$178.11
10' – 2×6	33	$6.50	$214.5	12%	$188.76
16' – 2×10	48	$18.76	$900.48	8%	$828.44
Subtotal					$1675.79
7% PST					$117.31
5% GST					$83.79
Total					$1876.89

Figure 1 – Using a table to calculate by the piece costs

Using a table helps to group items together and makes it easier to add columns.

Data Entry

The first step in calculating the costs is to enter the data into the table. Costs can be obtained over the phone, by requesting a quote, or from a supplier's website.

The first three columns (item, number of pieces, cost per piece) and the fifth column (discount) are the data. Enter all of the data before extending the costs.

Extending

Extending the calculations consists of multiplying the number of the item by the cost per item. The result of this calculation is entered into the fourth column (gross cost). Before calculating the next row, apply the discount to the gross cost and enter the result in the net cost column.

Compute all of the rows and then add up the net cost column. Apply the PST and the GST and then add them to the subtotal to obtain the total cost.

The calculations are simple but mistakes are easily made if the work is not well-organized.

If a computer is available, the calculations can be done using spreadsheet software. A spreadsheet is a table just like the one above that's set up to automatically extend and add the columns.

NOTES

NOTES

Sold by Lineal Measure

Calculating costs when the material is sold per lineal (linear) measure is very similar to calculating by the piece. Multiply the length of the pieces by the number of pieces to get the total length needed per item (Figure 2).

Item	Length per piece	Number of pieces	Total lineal feet	Cost per foot	Gross cost	Discount	Net cost
2×4	8	156	1248	$0.44	$549.12	12%	$483.23
2×4	12	46	552	$0.37	$204.24	12%	$179.73
2×6	10	33	330	$0.65	$214.50	12%	$188.76
2×10	16	48	768	$1.17	$898.56	8%	$826.68
Subtotal							$1678.40
7% PST							$117.49
5% GST							$83.92
Total							$1879.81*

** The total costs are slightly different than those in Figure 1 due to small variations in the cost per lineal foot.*

Figure 2 – Using a table to calculate lineal measure costs

Sold by Board Measure

Board feet measure is a volume measurement that's calculated in "board feet" (Figure 3). Each board foot has a volume of 144 cubic inches of lumber.

One board foot is one foot by one foot by one inch thick. The measurements are the nominal measurements of the board.

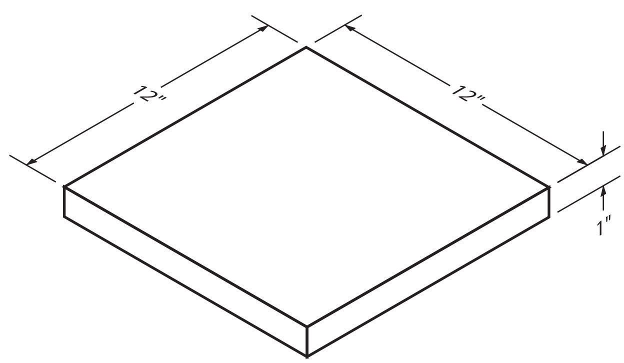


Figure 3 – One board foot

Calculations

NOTES

Calculating the number of board feet of lumber in a board or a pile of boards is relatively simple.

$$\text{Board Feet} = \frac{\text{Width} \times \text{Thickness}}{12} \times \text{No. of Pieces} \times \text{Length}$$

The length is measured in feet. The width and thickness are measured in inches. The product of the terms in the numerator of the above formula is divided by 12 to convert the width dimension of the lumber to feet to conform to the definition of a board foot as one foot by one foot by one inch.

Example

18 pieces of 2×8 that are 14 feet long is:

$$\text{Board Feet} = \frac{2 \times 8}{12} \times 18 \times 14 = 336 \text{ Board Feet Measure (BFM)}$$

Usually framing lumber is priced per thousand board feet. One thousand board feet is also referred to as one thousand board foot measure or MBFM. (The first "M" in the abbreviation indicates 1000—"M" is the Roman numeral for 1000.)

If the price for the 2×8 in the previous example is \$650.00 per thousand, the cost for the boards will be:

$$\text{Cost} = \frac{336}{1000} \times 650 = \$218.40$$

The number of board feet must be divided by 1000 to change it to MBFM. Then the number of MBFM is multiplied by the cost per thousand to obtain the cost.

Now complete Self Test 11 and check your answers.

Self Test 11

1. What is the cost for 68 pieces of 18' 2×8 if the price for each piece is $15.32?

2. What is the cost for 118 pieces of 12' 2×10 if the price is $0.92 per board foot?

3. What is the cost for 188 pieces of 14' 2×10 if the price is $0.72 per lineal foot?

4. What is the cost for 102 pieces of 18' 1×10 if the price is $675.92 per thousand board feet?

5. What is the cost for a $235.99 router if a 17% discount is given?

6. What is the cost (including PST and GST) for a $1235.99 table saw if both taxes are 7%?

7. What is the total cost of:
   12 – 18' 2×8 at $14.66 each

   165 – 8' 2×4 studs at $523.34 per thousand board feet

   450 lineal feet of 1×8 at $0.32 per foot

Allow a discount of 18% and add PST at 7%.

LEARNING TASK 12

Store Framing Materials Properly

NOTES

The care and handling of lumber at the job site and in the shop are very important aspects of the carpentry trade. Lumber is expensive and can be damaged very easily by careless handling.

Lumber

The delivery, organization, and care of lumber must be carefully considered for several reasons. Job site efficiency along with moisture content and warpage are the top concerns.

Delivery

Lumber orders arriving at the job site are usually made up of several sizes and lengths of lumber, sheets of plywood and/or OSB, and boxes of nails. Most orders will arrive on a truck equipped with a crane for unloading. Large job sites may have their own forklifts for unloading trucks. In some cases, trucks will have rollers and tilting decks. Small loads are sometimes unloaded by hand.

When unloading lumber onto a concrete pad or driveway, be careful not to break or damage the concrete. The same is true for blacktop pavement—in very hot weather, dunnage under lumber stacks can sink into pavement and leave permanent depressions.

Organization

Separate a new load of lumber into stacks of different types, sizes, and lengths. This makes the job site more efficient. Position each restacked pile so that it won't interfere with other deliveries or equipment in use.

Lumber usually arrives banded together in stacks. Safety glasses are extremely important when cutting banding. Stacks may fall over when banding is cut, which can easily cause broken bones. Stand well clear when cutting banding.

Place dunnage on the ground under each lumber stack to keep the wood off the ground and to allow the removal of rigging. Space it in an even plane no more than 1.2 m (4') apart to give full support to the lumber. (Dunnage not placed in an even plane will contribute to lumber warpage and twisting.) Place it high enough to position the lumber well off the ground.

Notes

If green lumber is stockpiled for a considerable time, place small strips of wood ("stickers") between each layer. Position the stickers immediately over the dunnage on the ground and directly over each other.

Lumber shipped to a job site will usually have a moisture content of 19% or less. The *BC Building Code* requires framing lumber to be no greater than this moisture level. When stored outdoors in a wet climate, lumber will increase its moisture content if not protected from the rain. Cover lumber with tarps, polyethylene (poly) sheets, or old sheets of lapped plywood.

When covering lumber with tarps or poly, allow air to circulate around the pile and do not allow the sides of the covering to reach the ground on at least two opposite sides. This will prevent ground moisture from being trapped and rom fungi from attacking the wood.

If lumber on top of a pile is exposed to direct sunshine, the wood is apt to warp as the exposed face dries out.

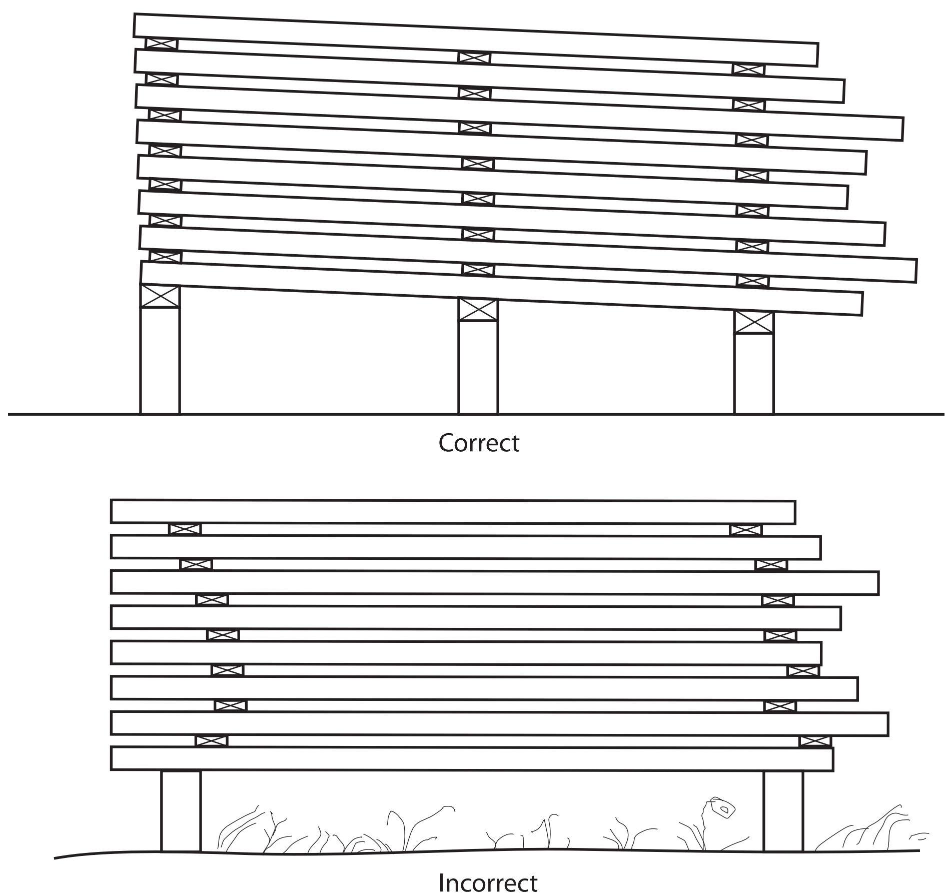


Figure 1 – (a) properly stacked lumber; (b) poorly stacked lumber

In Figure 1b there is no slope for water runoff and the stickers are poorly aligned.

Notes

Lumber stored indoors will pick up or lose moisture until it reaches a balance (equilibrium) with the moisture of the air in the room. If the storage area is heated and well-ventilated, the wood will usually lose moisture content.

If wood with high moisture content is used in a building with dry air, it will shrink. If very dry wood is used on a building exterior or in any outdoor application in a damp climate, it will swell. This is often why doors and windows stick and why sheathing sometimes buckles. It's also responsible for nail pops and squeaky floors.

When wood has the correct moisture content, swelling and shrinking are reduced to a minimum.

Care

Keep lumber as clean as possible. Do not allow a load to be dropped into mud. If the lumber will be exposed after construction, it must not be marred or stained. There must be no embedded dirt or sand because this can damage tools.

Plywood

Store plywood in a flat position to prevent warping. Store it with a slight slope well off the ground and cover it with tarps, poly, or other sheets of plywood. Keep it dry and as clean as possible. Allow for air ventilation under the stack.

When framing, it's not always possible to keep plywood sheathing dry until the roof has been placed. Plywood has waterproof glue to keep it from delaminating. It should be properly nailed before the end of the workday to keep it from warping.

Engineered Beams, Truss Joists, and Roof Trusses

Manufacturer's literature will normally accompany engineered products such as beams, truss joists, and roof joists. Always follow the manufacturer's instructions for storage, protection, and handling. Trusses are normally stored standing up rather than flat. Putting a bow or a twist in a truss can cause plates to loosen and possibly cause a catastrophic failure later under a heavy snowload.

Finish Materials

Store finish lumber and finish plywood indoors to keep it protected from the weather. It's important to store both off the floor so they do not absorb moisture or become dirty. Place them on strips of clean wood which are spaced no more than 1.2 m apart.

NOTES

Pile lumber neatly. Never use finish lumber or finish plywood for a workbench or lunch table. The wood should be sorted into different sizes, shapes, and lengths and covered with paper, plastic, or plywood to protect it from dust, paint, and the fading effects of sunlight.

Position stored lumber and plywood in places that make the wood easily accessible, yet out of the way. When moving wood or plywood in order to reach a work location, do so carefully and do not damage the edges and faces.

Conditioning

Finish materials (flooring, casings, baseboards, handrails, etc.) must be conditioned before installation. That is, it must be allowed to reach equilibrium moisture content (EMC). Storage locations should have a constant temperature and moisture content close to the future conditions of the finished building.

The building should be properly heated before finishing work is started. At least two to three days should be allowed for the wood to reach equilibrium moisture content.

☑ Now complete Self Test 12 and check your answers.

Self Test 12

1. Describe how to store lumber outdoors.

2. List two precautions when delivering material.

3. What is done with a mixed order of lumber after it has been delivered?

4. What does "equilibrium moisture content" mean?

5. Why should piles of lumber not be wrapped tightly in plastic?

6. Describe "conditioning" finish materials.

NOTES

LEARNING TASK 13

Select Fasteners Used in Frame Construction

There are many different fasteners used in frame construction. Some situations require fasteners with special properties such as shear strength, withdrawal resistance, or corrosion resistance. Nails are commonly sized by their length, although in the United States the penny (d) system has been used for many years. A 2" nail is a 6d and a 3" nail is a 10d.

Strength

Fasteners must resist both withdrawal and shear forces.

Nail Holding Power

The withdrawal strength of a fastener is its ability to resist being pulled out. This usually relies on the friction produced by side pressure. It can also be improved by angling nails in opposing directions and by staggering nails.

Size, shape, and surface treatment influence the holding power of a nail. Ring nails, ardox (spiral) nails, and galvanized nails all have increased withdrawal strength compared to bright nails.

Holding power is also determined by the type of wood. Hard wood has greater holding power than wood that's soft. If the wood splits when driving the nail, the holding power is significantly reduced. This can usually be prevented by blunting the point of the nail to allow it to cut through the wood's fibres as opposed to splitting them. In some cases, pre-drilling a pilot hole may be required to prevent splitting.

Nail Shear Strength

The shear strength of a fastener is its ability to resist lateral movement. A ledger, which supports deck joists, nailed to the boxing joist must resist the vertical shear load of the joists.

NOTES

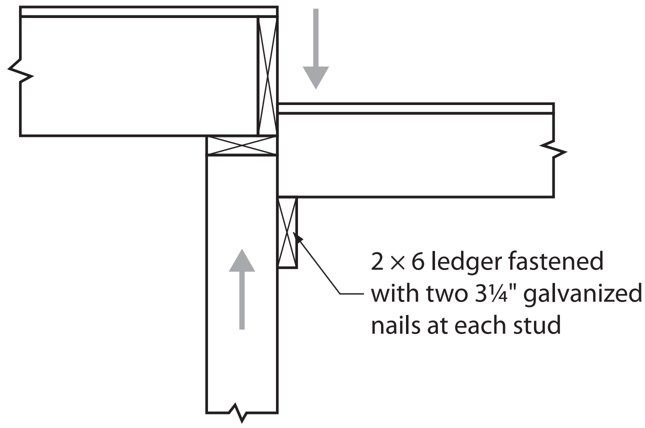


Figure 1 – Shear loading

The opposing forces at the ledger create a shear load on the nails. Pneumatic-powered nails and deck screws have less shear strength than comparable sized nails. Hanger nails are short galvanized nails with a thick shank that provides good shear strength.

Nail Finishes

Nails with a ***bright finish*** are used for general construction, including framing and attaching sheathing. They have a shiny smooth look when new. These nails rust when exposed to weather.

Hot-dipped ***galvanized nails*** are made for exterior use. They will resist rust and corrosion. The thick coating of zinc produces a very rough surface, which also increases the nail's holding power.

Electro-plated galvanized nails are not as resistant to rusting and are designed to be used where they will not be directly exposed to the weather (roofing and drywall nails).

Phoscoated nails are specifically designed for use with SPF lumber and are mainly used for drywall. 3¼" spikes are sometimes used for hand nailing of framing. Phoscoated nails are usually dark or black in colour and have a better resistance to moisture and withdrawal than bright finish nails.

Heat*-treated *nails have been treated to make them stronger and stiffer. They may also have higher carbon content. They're used for driving into very hard surfaces such as concrete.

Pneumatic gun nails can have various finishes, including bright, vinyl, adhesive, and galvanized. When the nail is driven, the heat cause by friction melts the vinyl or adhesive. When cooled, the finish bonds to both materialsc giving additional holding power.

NOTES

Types of Nails

Nails were hand forged up to about 1800. For the next 120 years, nails were stamped out of sheets of metal (and called square nails). Most nails are now made from cut wire.

Common Nail

The common nail is the most widely used nail. It's made from various gauges of wire, which are pressed into shape with a sharp point and a flat head. The head width is about three times the diameter of the shank (Figure 2). Common nails can be bright or galvanized.

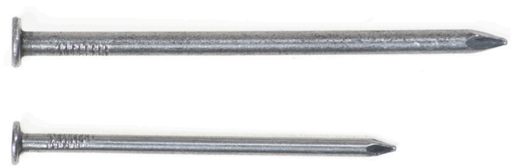


Figure 2 – Common nail

The main difference between common and finish or casing nails is that finishing and casing nails do not have large heads.

Duplex Nail

Duplex nails have a double head and are used for temporary nail placement. They're used for forming, scaffold building, etc. Duplex nails are usually bright.

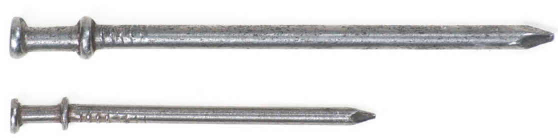


Figure 3 – Duplex nail

Hanger Nail

Hanger nails look like short common nails. They're designed to offer maximum resistance to shear when used with joist hangers and are available in bright or galvanized. In many cases, they're too short to be used with beam and truss hangers. Always check the engineering requirements when nailing these types of hangers.

Figure 4 – Hanger nail

NOTES

Ardox Nail

Ardox (spiral) nails are usually produced from square wire that has been twisted (Figure 5). The shank is thinner than that of a common nail of the same length. Its resistance to shear is lower but the holding power is superior (50–200% greater than a smooth-shank nail).

Figure 5 – Ardox (spiral) nail

This nail has a tendency to bend easily and is very difficult to remove. They should not be used for formwork construction.

Ring Nail

Ring nails are designed for increased holding power. They have ring-like ridges circling the shank. Common uses are for nailing subflooring and for use in pneumatic nailers. The HurriQuake nail by Stanley-Bostitch is a ring nail specially designed to resist the forces of hurricanes and earthquakes.

Figure 6 – Ring nail

Box Nail

Box nails are similar to common nails, except they have a smaller diameter shank. Because of this, they are weak in both shear and holding power, and they are also easily bent when driving. Box nails are used to nail thin wood to prevent splitting. They're not normally used for framing.

Concrete Nail

Concrete nails are made of high-carbon steel that has been heat-treated to increase its stiffness. To improve its resistance to withdrawal, the shank is hexagonal or octagonal in shape and slightly spiralled. The shank diameter is almost double that of a common nail of the same length.

Figure 7 – Concrete nails

Notes

Always wear eye protection when nailing—this is especially critical when driving concrete nails. The nail or chips of concrete can be sent flying when the nail is struck.

Pneumatic Fasteners

Most nailing is done with pneumatic-powered nailers. The fasteners for these tools come in strips or coils.

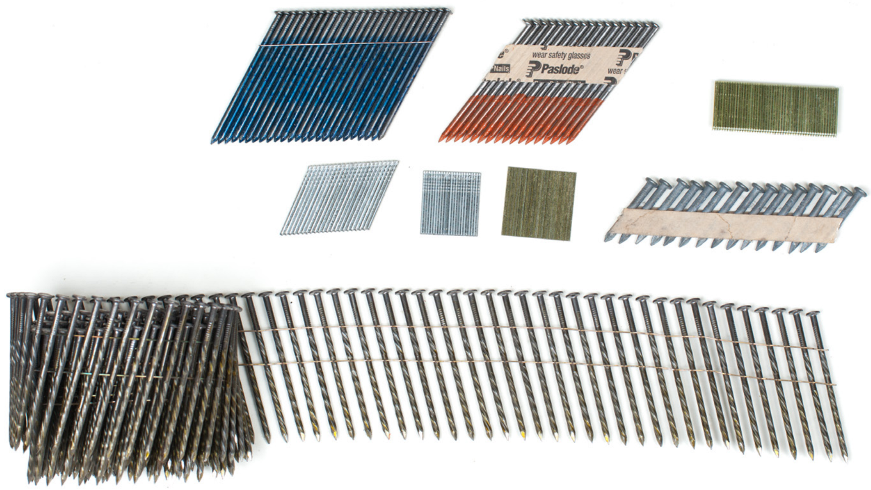


Figure 8 – Coil nails and strip nails

A wide range of staples are available for air-powered staplers (Figure 9). Ensure that the staples you use meet the *Building Code* requirements. Length, gauge, and crown are all factors that must be considered.

Figure 9 – Fasteners for air-powered staplers

Damage can be done to the nailer if the incorrect fasteners are used. Check that the fastener is compatible with the gun before loading.

NOTES

Stainless Steel Nail

Stainless steel nails are used when maximum corrosion resistance is required, such as for preserved wood foundations. They're also used in marine construction. Stainless steel nails are more expensive than most other types of nails. Other corrosion resistant nail materials include aluminum, brass, and copper.

Screws

Screws have become quite common in construction but are not always comparable to nails.

Deck Screws

The subfloor in quality construction is fastened with deck screws. These screws come in a variety of lengths and finishes. The length of the screw should be at least 1¼" longer than the thickness of the subfloor.

Screws are available in coils, which are designed to be used with a screw gun. The gun is operated from a standing position.

Some deck and concrete screws are available with epoxy coating.

Structural Screws

Simpson Strong Tie Strong Drive structural screws are design to work like a lag bolt. They're manufactured for many purposes, including laminating engineered beams, laminating girder trusses, and other applications. Some have a wafer head that acts as a combined screw and washer.

Bolts

In special situations, framing is joined together using machine, carriage, or lag bolts. Bolts are sized by their shank diameter and length. They're typically available in steel, galvanized steel, and stainless steel.

Machine Bolt

Machine bolts have a square or hex head and are used with nuts. Washers are used to increase the effective area of the head and nut and to facilitate tightening. Machine bolts are sometimes used to bolt girder trusses together or to bolt machines or columns to concrete.

Figure 10 – Machine bolt, nut, and washer

NOTES

Carriage Bolt

Carriage bolts have a low profile round head. They're used when security is an issue or when a head isn't desired, such as for the hinged corners of concrete forms.

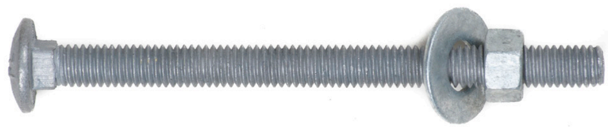


Figure 11 – Galvanized carriage bolt, nut, and washer

Lag Bolt

Lag bolts are like very large wood screws and have a square or hex head designed to be turned with a wrench. They're often used to anchor wood ledgers or steel members to beams or plates.

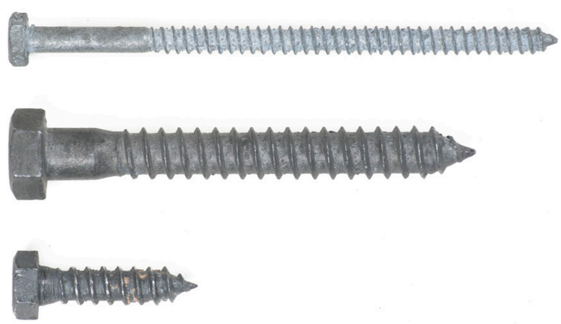


Figure 12 – Lag bolts

Construction Adhesive

Construction adhesive is typically used when installing subflooring. It will greatly increase the stiffness of a floor. Adhesive is also used for applying sheathing in engineered wood-frame shear walls. Modern adhesive adheres even if the wood is not completely dry, but for best results use adhesive in dry weather.

It's very important to completely fasten the sheathing before adhesive sets up.

Construction adhesive is available in small and large caulking tubes. Pneumatic caulking guns are available that apply a very smooth bead of glue.

NOTES

Effects of Wood Preservatives

ACQ is the main preservative used for pressure-treated lumber. It's twice as corrosive as the CCA preservative that was used in the past. Corrosive-resistant fasteners must be used when working with ACQ lumber. In dry locations, such as nailing to a pressure-treated sill plate, hot dipped galvanized fasteners can be used. Stainless steel or epoxy-coated fasteners should be used for wet locations such as exterior decks.

☑ Now complete Self Test 13 and check your answers.

Self Test 13

1. List two reasons to use a coated nail.

2. Which type of nail is suited for exposure to the weather?

3. Name three types of nails that have a better withdrawal resistance than a bright common nail.

4. Describe the difference between "shear" and "withdrawal."

5. What special safety concerns are there for driving concrete nails?

6. When using construction adhesive, you must completely nail the sheathing before ____________________.

7. What kind of fasteners must be used with ACQ-treated lumber?

LEARNING TASK 14

Select Framing Hardware and Indicate its Use

NOTES

The variety of framing hardware available is extensive. Choosing the appropriate hardware for a given situation is important. Using the wrong size or type of hardware can lead to building failures and result in costly repairs. Most framing hardware can be broken down into the following categories:

- fasteners
- concrete anchors and connectors
- masonry connectors
- hold-downs and tension ties
- post/column caps and bases
- lateral (shearwall) systems
- solid lumber connectors
- glulam beam connectors
- engineered wood connectors
- truss connectors
- straps and ties
- deck and fence connectors

When choosing framing hardware, the first step is to determine the type of materials being used: sawn lumber, engineered products, preservative-treated lumber, concrete, or masonry.

Engineered Wood Products

Engineered building components are often held in place with hangers and other hardware. Hardware is specified by the engineer according to each application. When installing joist hangers and framing anchors, double-check that the correct item is being used for the location as shown on the engineering drawings. Often fastener types, length, and gauge will be specified for use with each type of hardware.

Hangers may look the same but they have specific load carrying ratings and uses. Check that the product numbers stamped on the hardware match those described in the specifications and drawings.

NOTES

Joist Hangers

Metal joist hangers are used to support floor, ceiling, and roof joists.

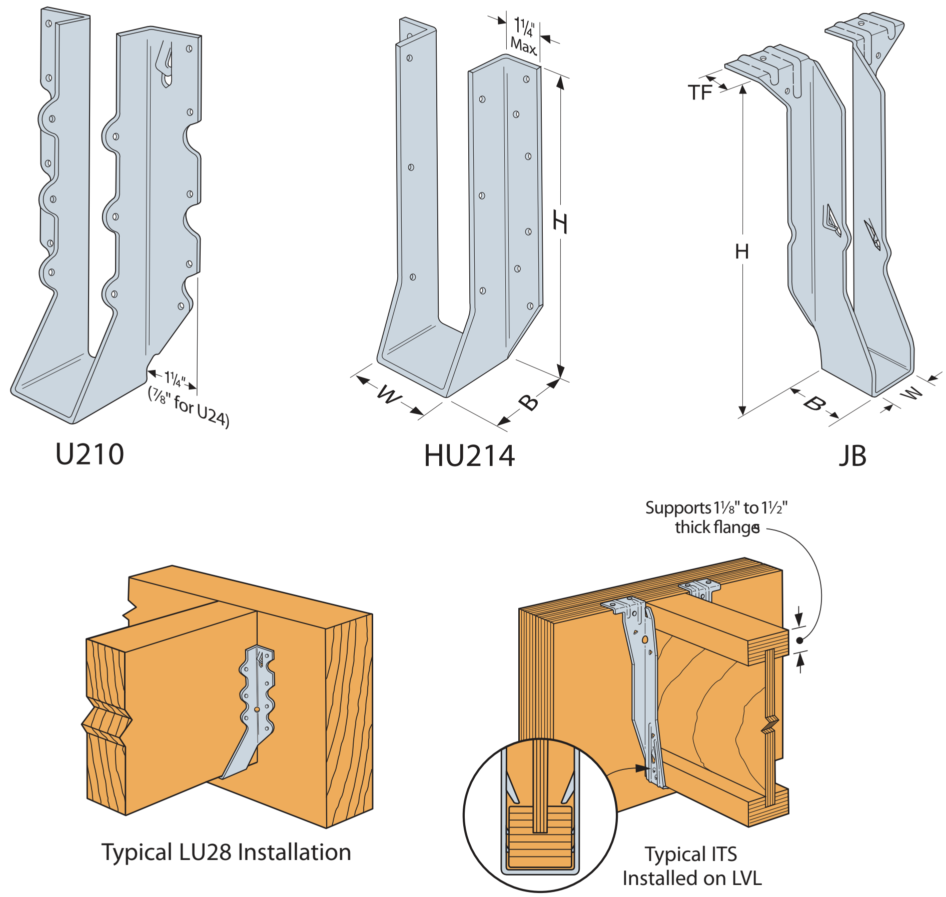


Figure 1 – Joist hangers

There are literally hundreds of different sizes and shapes of joist hangers. Those on the right of Figure 1 are used to connect "I" joists to a PSL beam.

Special angled hangers are available for hip and valley beams. They have a "skewed" or angled support for the beams.

Top hung floor joist hangers can be used to allow the top of the floor system to be flush with the foundation wall sill plate instead of having the floor system sitting on top of the sill plate. This allows a level entry way, making the building more accessible for physically impaired people.

Framing Anchor

A framing anchor holds two cross members together. It's also used at T-joints to connect members.

NOTES

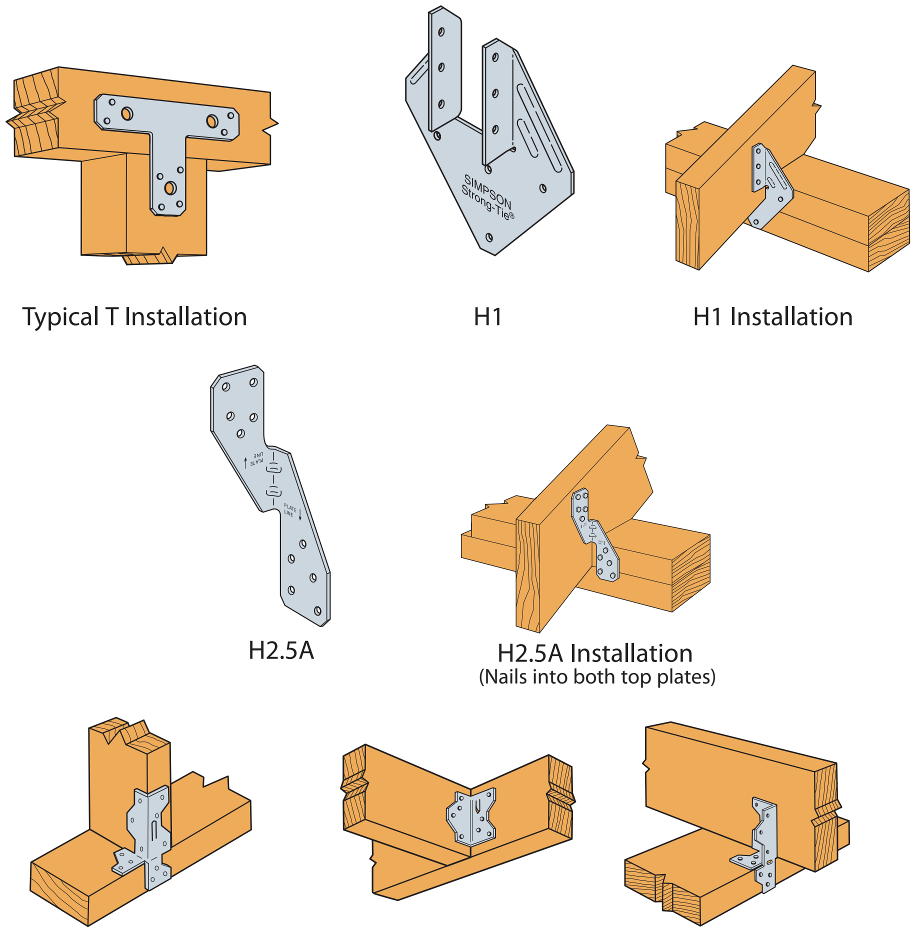


Figure 2 – Framing anchors

Structural Anchors

Structural angles and hold-downs are used to connect intersecting beams or girders. They're also used to secure vertical posts and shear walls to the foundation.

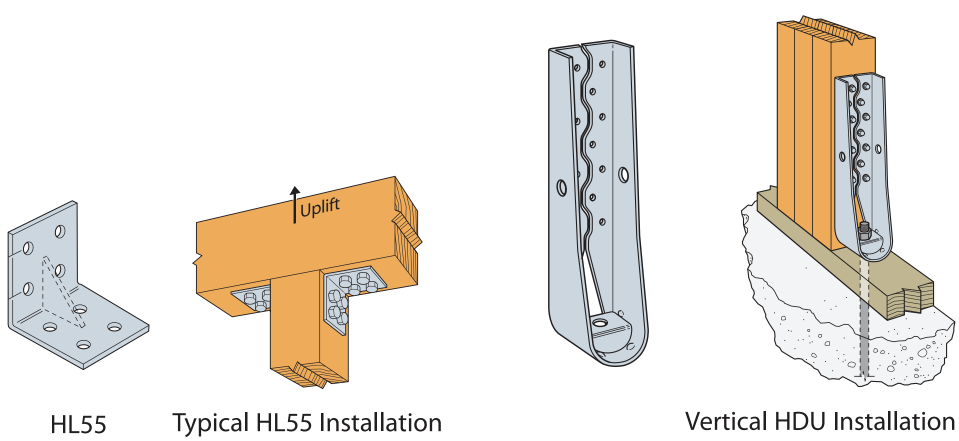


Figure 3 – Structural angles and hold-downs

NOTES

Column Supports

Column (post) anchorage is very important in locations where high winds can create extreme up-lifting forces.

Figure 4 – Column anchor

Column and beam connectors secure a beam to a column or a column to a concrete foundation. They're available for different-sized lumber and beams.

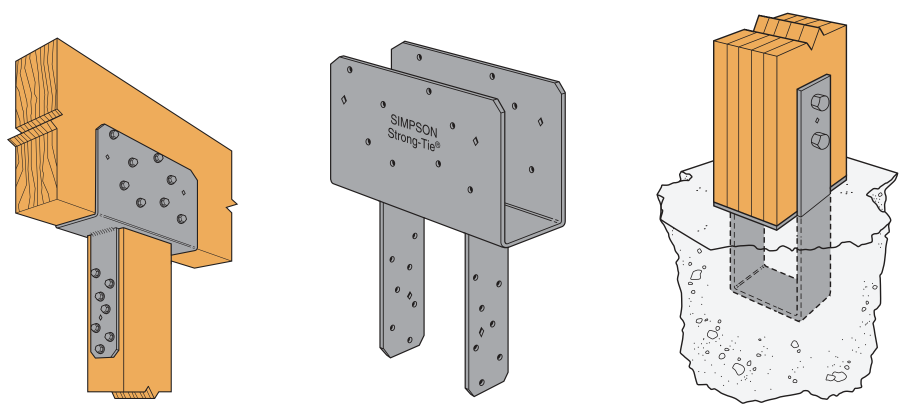


Figure 5 – Column and beam connectors

Structural Strap and Connector Plate

A structural strap, which has punched-out holes over its full length, is used for wall bracing (Figure 6). It can be used on the exterior face of a stud with no notching or cutting required. The *BC Building Code* allows the use of straps to tie ceiling joists when joints are butted.

NOTES

The plate, which comes in a range of shapes and sizes, is used to reinforce joints or to splice beams. It can also tie a beam to a ridge or wall. It's pre-punched to allow for nailing or bolting in a heavier plate.

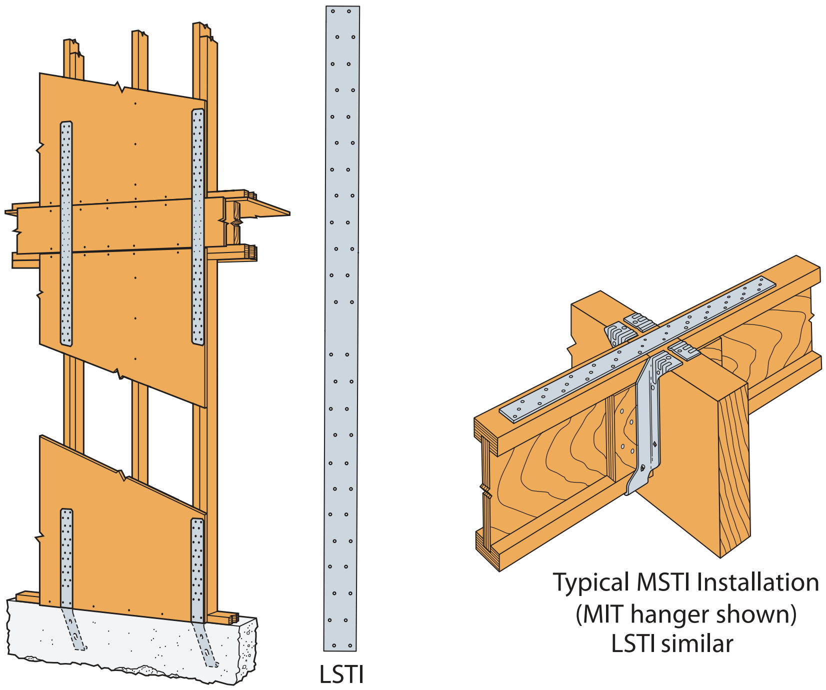


Figure 6 – Structural strap and plates

Cross-bridging

Metal cross-bridging is used in a similar manner as wooden bridging. In the installation of one type of cross-bridging, a prong is driven into the joist at the top and the bottom is end nailed. One advantage is that this type of cross-bridging can be installed after the floor sheathing has been completed. The type of cross-bridging shown in Figure 7 needs to be installed before floor sheathing.

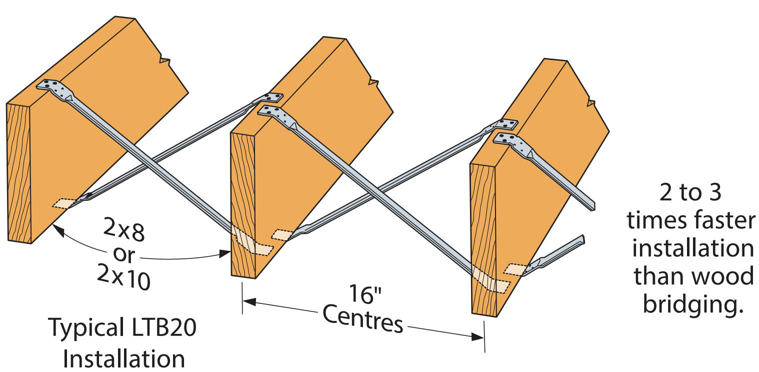


Figure 7 – Cross-bridging

NOTES

Seismic Hardware

Seismic hardware is used to hold down buildings and to laterally brace buildings. Often the hold-downs will run from the foundation to the upper wall plates of the top floor level. Threaded rods and coupling nuts are used to extend the hold-down as the building rises floor by floor.

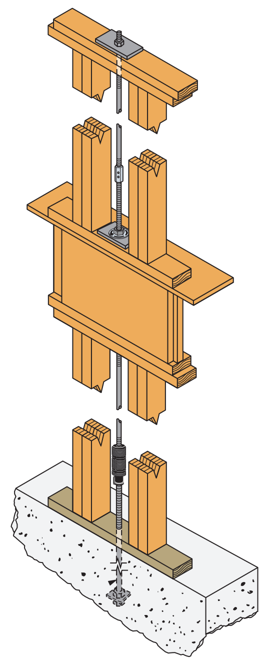
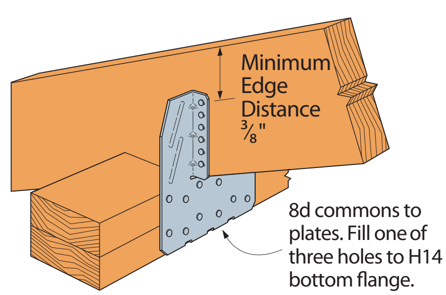


Figure 8 – Simpson Strong-Tie Anchor tie-down system

High Wind Hardware

Hurricane force wind can sometimes tear the entire roof system off a building. Typically only three nails, toenailed into the top plate, hold down a truss or rafter where it meets the wall. Wood can easily split at this location. "Hurricane clips" are various types of framing anchors used to strengthen the tie between the top plate and trusses or rafters.



H14 Installation to double top plates

Figure 9 – Simpson Hurricane Tie

NOTES

Hardware for Preservative-treated Lumber

Due to the corrosive nature of preservative-treated lumber, any hardware used must be corrosion-resistant. This may require the hardware to be painted, epoxy coated, hot dipped galvanized, or stainless steel. The requirements will depend on the type and penetration of the preservative, the location of the hardware (interior or exterior use), and the amount of moisture it will be exposed to.

Installing Framing Hardware

Most framing hardware is engineered and tested to certify its load-carrying capacity. Hardware must be used in a manner prescribed by the manufacturer and installed with the prescribed fasteners. Unless specified by the manufacturer, hardware should never be cut, bent, or drilled.

☑ Now complete Self Test 14 and check your answers.

Self Test 14

1. What is the first step when choosing framing hardware?

2. In what locations is column anchorage especially important?

3. What should be done when installing joist hangers for an engineered floor?

4. What is a “structural strap” used for?

5. What is a “connector plate” used for?

6. How are seismic hold-downs extended?

7. What quality must framing hardware have when used with preservative-treated lumber?

Answer Key

Self Test 1

1. platform-framing
2. post, beam, and plank (heavy-timber)
3. to support the concentrated (point) loads
4. platform-framing
5. post, beam, and plank construction, or if framing members are more than 24" o.c.
6. *Part 9*
7. platform- or balloon-framing
8. a complete review of the structural design
9. cement stucco and masonry veneer
10. an area of significantly lower insulation levels due to the location of framing materials
11. western platform-framing

Self Test 2

1. a. gable roof
   b. Dutch hip
   c. intersecting gable
   d. flat roof
   e. hip roof
   f. Mansard
   g. shed
   h. gambrel
   i. butterfly
2. a valley
3. Dormers are added to the roof design.
4. gable

Self Test 3

1. Girders are large beams that support other beams.
2. i. lintel and header
   ii. cripple stud and trimmer stud
   iii. jack studs and cripple studs
3. Trimmer joists are spanning joists which run parallel with the main joists and support header joists. Header joists run perpendicular to the main joists and support tail joists.
4. to stiffen walls or to act as fire stops
5. i. cripple studs
   ii. jack studs
6. i. ceiling joists
   ii. roof joists
   iii. collar ties
   iv. strapping
   v. roof trusses
7. Purlins are structural members that run at right angles to the rafters.
8. i. supports finishes
   ii. provides lateral support
   iii. braces floor, wall, or roof diagonally
9. in roof framing to reduce the span of rafters

Self Test 4

1. no
2. the staggering of joints in plates or sheathing
3. A camber is an intentional upward curve built into a manufactured beam or girder. A crown is a lumber defect due to warping.
4. cornice or eave
5. obtain the correct rough opening size from the manufacturer or supplier
6. a wall that extends above the roofline

Self Test 5

1. wood: approximately 500–600 kg/m^3
   steel: 8000 kg/m^3
   concrete = 2400 kg/m^3
2. Wood is a better insulator than metal, therefore the wood is warmer, reducing the chance of warm moist air condensing on the frame.
3. If wooden construction members are removed carefully they can be reused. Remove all nails. For finish material, pull nails through the backside of materials to reduce damage to face of materials.
4. 40–100 years
5. i. waferboard
   ii. fibreboard
   iii. particleboard
   iv. oriented strand board (OSB)
   v. laminated veneer lumber (LVL)
   vi. parallel strand lumber (PSL)
   vii. glue laminated beams
   viii. plywood
6. swells or shrinks
7. wood

Self Test 6

1. plain sawing
2. quartersawing
3. greater than 45°
4. Plain sawing is when the boards are cut through the full width of the log.
5. S1S2E
6. surfaced green

Self Test 7

1. roots, trunk, crown
2. a. heartwood
   b. sapwood
   c. inner bark
   d. outer bark
   e. annual growth rings
   f. cambium layer
   g. rays
   h. pith
3. i. f. (cambium layer)
   ii. b. (sapwood)
   iii. h. (pith)
   iv. g. (rays)
   v. d. (outer bark)
   vi. a. (heartwood)
   vii. c. (inner bark)
   viii. e. (annual growth rings)
4. a. true
5. a. bound water
6. Once all of the free water is gone from the cells and bound water starts to leave.
7. width and thickness (along growth rings)
8. flat grain
9. western larch
10. western red cedar
11. Douglas fir, larch, hemlock
12. western hemlock
13. Sitka spruce
14. spruce, some species of pine, balsam fir, alpine fir
15. western red cedar

Self Test 8

1. All decay in wood is caused by the invasion of fungi.
2. no
3. brown rot, white rot, dry root
4. i. ensure framing lumber has a moisture content less than 20%
   ii. ensure that wood placed in service has adequate ventilation
   iii. treat wood to prevent fungus attack when placed in areas of high moisture
5. a. ring shake
   b. carpenter ant damage
   c. star shake
   d. powder-post beetle damage
6. i. improper seasoning techniques
   ii. improper handling
   iii. improper storage
7. a. cup
   b. bow
   c. twist
   d. diamonding
   e. crook (crown)
   f. kink
8. incorrect seasoning or it may occur naturally due to grain
9. carpenter ants
10. western subterranean termite
11. powder-post beetle
12. chipped grain
13. darkening of the wood due to machine knives or rollers getting overheated when pieces are stopped in the machine
14. They occur during dressing when shavings or chips become embedded in the surface of the material.
15. A twist is a deviation that occurs flat-wise, or it is a combination of flat-wise and edge-wise deviations which take the form of a twist or spiral.

Self Test 9

1. Lumber that is passed through a device that measures how much the actual piece of lumber will bend or flex under a given load.
2. critical members in engineered wood trusses
3. construction, standard, utility, economy
4. select structural, number 1, number 2, number 3
5. 1½" × 5½"
6. 1⁹⁄₁₆" × 7½"
7. 310–340 kg/m^3
8. greater than 1.0

Self Test 10

1. i. plywood
   ii. OSB
   iii. waferboard
2. Cross-banding is when the layers of veneer in plywood manufacture are laid at right angles to one another.
3. 47½"
4. OSB is manufactured in very large sheets, just over 12' × 24', whereas logs for plywood are cut to just over 8' in length.
5. painted edges and drainage holes spaced along the tongue
6. Sheathing Grade. No

Self Test 11

1. $1041.76
2. $2171.20
3. $1895.04
4. $1034.16
5. $195.87
6. $1409.03
7. $684.78

Self Test 12

1. Keep lumber well off the ground with the use of dunnage, stacked with a slight slope, sticker the pile if necessary, and cover with a tarp, plastic sheet (poly), or plywood to protect the wood from direct sunlight and rain.
2. Place dunnage under the load to assist removal of the rigging and/or banding from around the pile. Take care not to damage concrete or paved surfaces.
3. separate into stacks of different types, sizes, and lengths
4. Equilibrium moisture content is when the moisture content in the wood is equal to the humidity level of the surrounding air.
5. If wrapped tightly in plastic, the lumber will not be able to breath and rot may occur.
6. Conditioning of materials is when material is stored in or as close as possible to the location where it will be installed to allow the moisture content in the wood to match the humidity level in the surrounding air.

Self Test 13

1. i. to prevent corrosion
   ii. for better holding power
2. i. hot-dipped galvanized
   ii. stainless steel
3. i. ardox
   ii. ring
   iii. galvanized
4. Withdrawal is the ability to resist being pulled out, and sheer is the ability to resist lateral movement.
5. wear safety glasses
6. the adhesive sets up
7. corrosion-resistant fasteners

Self Test 14

1. determine the type of material being used
2. locations where high winds can create extreme up-lifting forces
3. double check that the correct hardware is being used according to the engineering drawings
4. used for wall bracing
5. to reinforce joints or to splice beams
6. with threaded rods and coupling nuts
7. corrosion-resistance