Specified Skilled Worker (i) Evaluation Test Study Textbook (First Edition)

Lumber Industry Sector

<Introduction>

This textbook is designed for those who wish to work in the lumber industry (e.g. sawmills) under the Specified Skilled Worker (i) residence status to learn basic knowledge and skills.

In this textbook, a wide range of basic knowledge and skills about wood, the lumber industry, and work safety are introduced.

In some workplaces, the way of working or the words used may be different from what is written in this textbook. If that happens, please follow the way things are done at your workplace. Even if the methods or terms are different, the basic idea is the same.

<About the Test>

How the Test is Conducted: Written Test
Languages: Japanese (with kana readings provided for the kanji)
Test Time: 60 min.
Number of Questions: 35 questions (32 written questions [true/false format], 3 practical questions [judgment test])
Test Scope:

	Topic
Written Test (General) Score Allocation: 56 points	Overview of Forests, Forestry, and the Lumber Industry
	Properties of Wood
	Work Safety
Written Test (Specialized) Score Allocation: 18 points	Manufacturing Processes for Each Product
	Machines and Equipment Used
	Use of Each Product
Practical Test Score Allocation: 26 points	Work Procedures / Safety and Hygiene / Calculation Questions

【Table of Contents】

You may study this textbook in order from the beginning, but as shown in the table below, you may also focus on the chapters marked with a ○ depending on the type of factory where you plan to work.

Chapter	Sawmilling	Laminated Wood	Plywood	LVL	Veneer	Flooring	Wood Chips	Pre-cutting
1	○ (This is knowledge required in all types of work)							
2.1	○							
2.2		○						
2.3			○					
2.4				○				
2.5					○			
2.6						○		
2.7							○	
2.8								○
3.1	○							
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3.3			○	○				
3.4					○			
3.5						○		
3.6							○	
3.7								○
4.1	○							
4.2		○						
4.3			○	○	○			
4.4						○		
4.5							○	
4.6								○

Chapter 1: Basic Knowledge of Forests, Forestry, and the Lumber Industry

1.1 Forests, Forestry, and the Lumber Industry in Japan

(1) Current State and Multifunctional Functions of Japan's Forests

About two-thirds of Japan's land area is covered by forests. Of these, about 40% are "planted forests" that have been planted and cultivated by people. Many of these planted forests are now over 50 years old and have reached the stage where they can be used as wood, so it is important to make effective use of them.

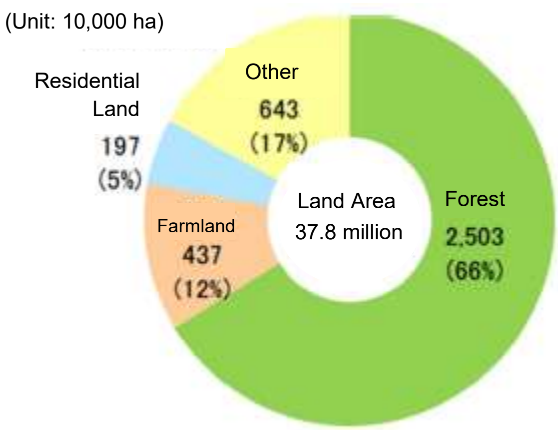


Figure 1-1: Breakdown of Land Area

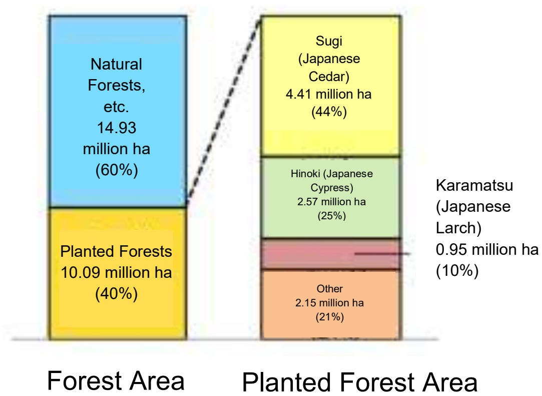


Figure 1-2: Planted Forest Area by Tree Species

Forests not only provide wood, but also have many other functions, such as preventing landslides, purifying and storing water, and helping to prevent global warming. These roles of forests that support our daily lives are called their "multifunctional roles."

(2) The Importance of Wood Use

Trees can store carbon by absorbing carbon dioxide from the atmosphere. For this reason, when wood taken from forests is used in buildings and other structures, it can store carbon for a long time.

In addition, compared to materials such as steel and concrete, wood requires less energy for manufacturing and processing. Therefore, using wood in buildings also helps reduce carbon dioxide emissions.

In this way, the use of wood contributes to preventing global warming. It is important to cut trees, use the wood carefully, and then plant and grow new trees in the areas where the trees were cut.

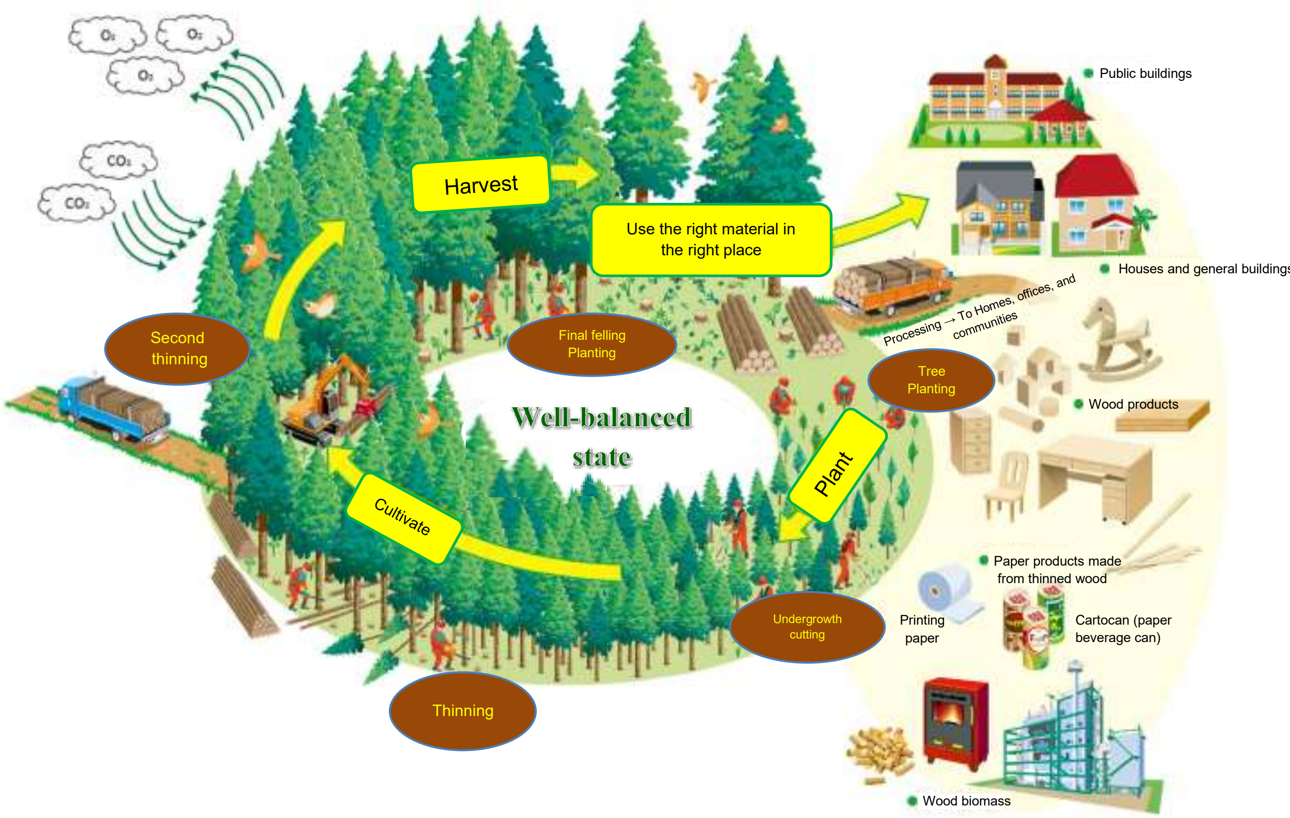


Figure 1-3: Image of the Recycling Use of Forest Resources

(3) Japan's Wood Industry

The wood industry buys logs and raw materials from forest owners and others, processes them, and sells the products. Here, Japan's wood industry is explained by business category.

① Sawmilling Industry

In 2022, the shipment volume of lumber was 8.6 million m^3, and it has remained almost unchanged in recent years. About 80% of this is construction material, while the rest includes packaging material, civil engineering materials, and materials for furniture and fittings.

In sawmills, straight logs called "A-grade logs" are often used to produce products such as pillars for houses. About 80% of the logs used are domestically produced, while the remaining 20% are imported. Among imported logs, many come from North America (the United States and Canada), known as "North American wood."

There are about 4,000 sawmills in Japan, but this number has been decreasing in recent years.

② Laminated Wood Manufacturing Industry

Laminated wood is made by aligning thin boards or small square wood in the same grain direction and then stacking and gluing them together in the width or thickness direction.

In Japan, the production volume of laminated wood in 2022 was 1.66 million m^3, most of which was structural laminated wood. About 47.1%, nearly half, of this is made using domestic wood, and the proportion has been gradually increasing compared to the past.

As of 2022, there were 140 laminated wood factories in Japan.

③ Plywood Manufacturing Industry and LVL Manufacturing Industry

Plywood is a sheet material made by peeling thin layers called "veneer sheets" from a rotating log and gluing them together so that the grain directions cross at right angles (90°).

LVL (Laminated Veneer Lumber) is made by laminating veneer sheets of 2–4 mm thickness, usually with the grain direction running in parallel, and is mainly used as structural members.

In Japan, the production volume of ordinary plywood in 2022 was 3.06 million m^3, most of which was made from softwood. By use, 2.66 million m^3 was structural plywood and 0.03 million m³ was concrete form plywood, among others.

Until about 20 years ago, most of the logs used in plywood factories were imported, but now about 90% are domestically produced. By tree species, sugi accounts for about 60%, followed by karamatsu and hinoki.

As of 2022, there were 155 plywood factories in Japan.

In addition, the production volume of LVL in 2022 was 0.25 million m³, and there were 12 LVL factories in Japan.

④ Flooring Manufacturing Industry

Flooring manufacturing in Japan began around the 1910s. In the past, the primary raw materials were domestic hardwood and imported hardwood, but in recent years the use of domestic softwood has been increasing.

As of 2024, there were 38 flooring factories across Japan.

⑤ Wood Chip Manufacturing Industry

The production volume of wood chips (excluding fuel chips) was 5.28 million tons in 2022, and this has remained almost unchanged in recent years. Raw materials include logs (45%), mill residues (40%), as well as forest residues, demolition wood, and waste wood.

Most of the logs used as raw materials are domestically produced. In recent years, the use of softwood has been increasing compared to hardwood.

As of 2022, there were 1,110 wood chip factories in Japan. Of these, 790 were combined with sawmills and other facilities, while 320 were dedicated wood chip factories.

⑥ Pre-cut Lumber Manufacturing Industry

Pre-cutting refers to the processing of structural members used in wooden houses, such as cutting the parts and shaping the joints and connections that link them, carried out in factories in advance by machines before bringing them to the construction site.

Pre-cut lumber is mainly used in Japan's most common wooden house construction method, the post-and-beam method. The use rate of pre-cut processing in this method has been increasing year by year, reaching 95% in 2023.

【Glossary】

Joint: The joining of two members lengthwise, or the location where they are joined.
Joinery: The joining of two members at a right angle or an oblique angle, or the location where they are joined.

1.2 Basic Knowledge of Wood

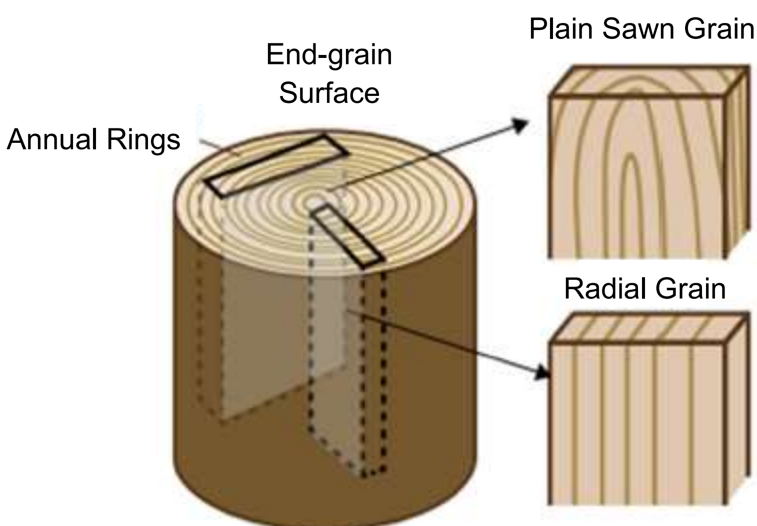
(1) The Three Cross-sections of Wood

The three cross-sections of wood are the "end-grain surface," the "quarter sawn surface," and the "plain sawn surface."

The "end-grain surface" is the cross-section cut perpendicular to the trunk, where concentric ring patterns appear. The "quarter sawn surface" is the longitudinal section cut through the center of the trunk, where parallel line patterns appear. The "plain sawn surface" is the section cut tangentially to the circumference of the trunk, where radial grain patterns usually appear.

(2) Annual Rings

When trees grow in regions with distinct seasonal changes, such as Japan, concentric ring patterns appear on the end-grain surface. This pattern is formed by the repetition of light-colored "earlywood," which develops during the favorable growing season from spring to summer, and dark colored "latewood," which forms from summer to autumn. Since usually one such pattern is formed per year, it is called an "annual ring."



Source: Educational Textbook on the Use of Wood: "Basics of Wood"

Figure 1-4: Cross-sectional View of Wood

(3) Heartwood and Sapwood

The darker-colored part near the center of a log is called “heartwood,” and the lighter-colored part around it is called “sapwood.” The coloration of heartwood differs depending on the tree species, and in some species the color distinction between heartwood and sapwood is not very clear.

For example, in sugi, a common species in Japan, the difference between heartwood and sapwood is obvious, while in hinokis it is somewhat less distinct.

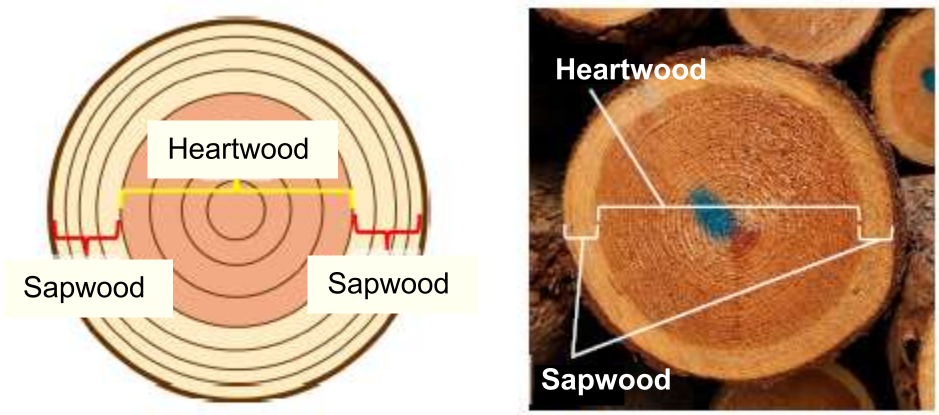


Figure 1-5: Heartwood and Sapwood

(4) Softwood and Hardwood

Wood can be divided into softwood and hardwood, and the cells and tissues that make up each are different.

Softwood trees generally have straight trunks, allowing them to produce long lumber along the grain, so they are used as structural materials such as pillars and beams.

Hardwood, on the other hand, varies more in trunk shape, hardness, weight, and grain patterns than softwood. In some species, distinctive patterns with artistic value appear on the wood surface. These are called “figures,” and they are given different names depending on their type.

Table: Major Tree Species in Japan Used as Wood

	Tree Species	Description
Softwood	Sugi (Japanese Cedar)	This is the most common species in Japan and is found in all 47 prefectures. It has a straight form and is easy to process, making it suitable for various applications, including construction materials. The distinction between sapwood and heartwood is clear, with the heartwood usually reddish in color. Sometimes, dark brown heartwood, called "black heart," also appears.
	Hinoki (Japanese Cypress)	This is the second most common species after Japanese cedar, and is found in regions south of Fukushima Prefecture on Honshu. The sapwood is yellowish white, while the heartwood ranges from light yellowish brown to light reddish. It is used for a wide variety of purposes, including high-grade construction materials.
	Karamatsu (Japanese Larch)	This deciduous softwood grows in cold regions such as Hokkaido and Nagano Prefectures. The sapwood is white, and the heartwood is brown. Small-diameter logs have drawbacks such as being prone to warping. In addition to being used for lumber, it is also used for plywood, piles, and other civil engineering materials.
	In addition, there are pine species (akamatsu [Japanese red pine] and kuromatsu [Japanese black pine]), todomatsu (todo fir), and yezomatsu (Yezo spruce).	
Hardwood	Representative species include mizunara (Japanese oak), sen (Japanese ash), buna (Japanese beech), kanba (birch), and keyaki (Japanese zelkova).	

(5) Small End and Large End of a Log

The end-grain surface on the treetop side of a log (the upper, narrower side of the tree) is called the "small end," while the end-grain surface on the root side (the lower, thicker side) is called the "large end." These terms may also be used for sawn products if their original top and bottom can be identified.

When used as pillars, it is a rule to place the large end at the bottom, just as it was when the tree was growing.

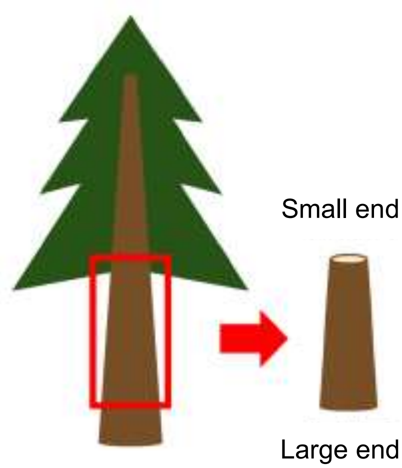


Figure 1-6: Small End and Large End of a Log

(6) Bark Side and Pith Side

On the flat-grain (tangential) surface, the side facing the bark (the outside of the log) is called the "bark side," and the side facing the pith (the inside of the log) is called the "pith side."

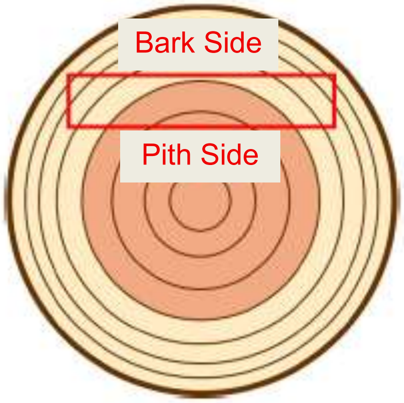


Figure 1-7: Bark Side and Pith Side of Wood

(7) Moisture Content

Wood contains moisture, and the ratio of the mass of this moisture to the oven-dry mass of the wood (the mass when it contains no moisture at all) is called the "moisture content."

$$\text{Moisture Content (\%)} = \frac{\text{Mass with Moisture} - \text{Oven-dry Mass}}{\text{Oven-dry Mass}} \times 100$$

When wood is left in the air for a long time, its moisture content reaches a certain level. This is called the "equilibrium moisture content." The value differs depending on the climate, but in Japan it is about 15% on average.

(8) Strength of Wood

The strength of wood varies depending on the way and direction in which force is applied. Its strength is expressed in terms such as (1) compressive strength, (2) tensile strength, (3) bending strength, (4) shear strength, and (5) splitting strength.

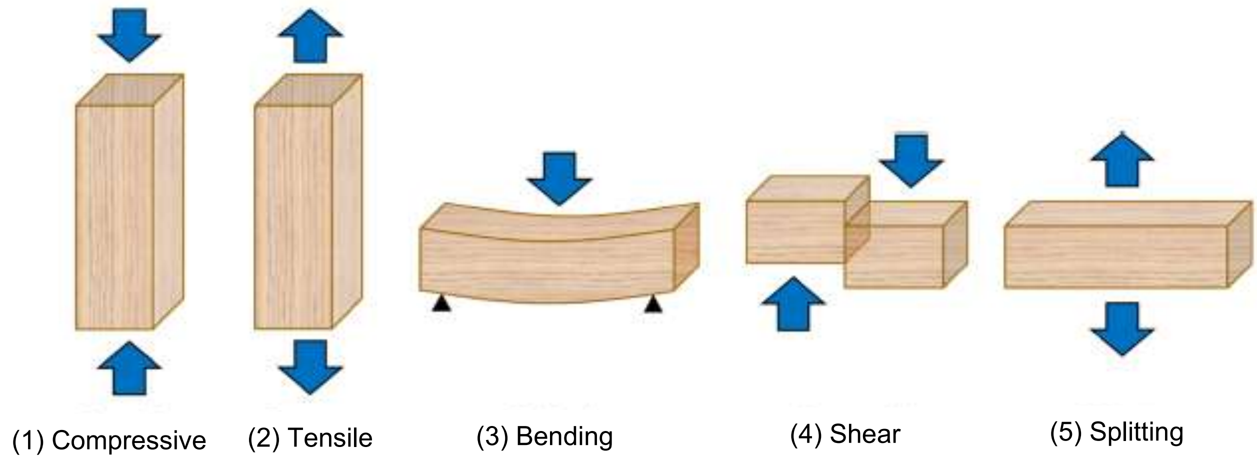


Figure 1-8: Types of Wood Strength (Image)

The following factors affect the strength of wood:

Density: In general, the higher the density, the greater the strength.

Moisture Content: Strength is greatest at a few percent to around 10%. Above the fiber saturation point (about 30%), strength remains almost constant.

Fiber Direction: Compressive and tensile strengths are greatest along the fiber direction (the direction of the trunk). In lateral directions, radial strength (from the center outward) is greater than tangential strength (along the annual rings).

Knots: Fiber distortion around knots reduces strength. Knots affect tensile strength more than compressive strength.

Other factors, such as wood temperature, position within the tree trunk, proportion of latewood, average ring width, size, and defects such as reaction wood or decay, also influence strength.

1.3 Basic Knowledge of Work Safety

(1) Occurrence of Occupational Accidents in the Lumber Industry

In the lumber industry, there are approximately 1,000 cases of occupational accidents resulting in injury or death each year. Among these, about 10 cases involve fatalities.

Thanks to the development of safer machinery and the promotion of safety measures, the number of accidents has decreased compared to the past. However, the incidence rate of occupational accidents is still 4.4 times higher than in other manufacturing industries, indicating that much improvement is still needed.

About half of the accidents in the lumber industry are caused by “cuts and abrasions” or by being “caught or entangled” in machinery. Many accidents that occur during wood processing happen when workers come into contact with high-speed rotating tools, or when they become caught in belts or feeding devices that drive the tools. Extreme caution is therefore required when performing these tasks.

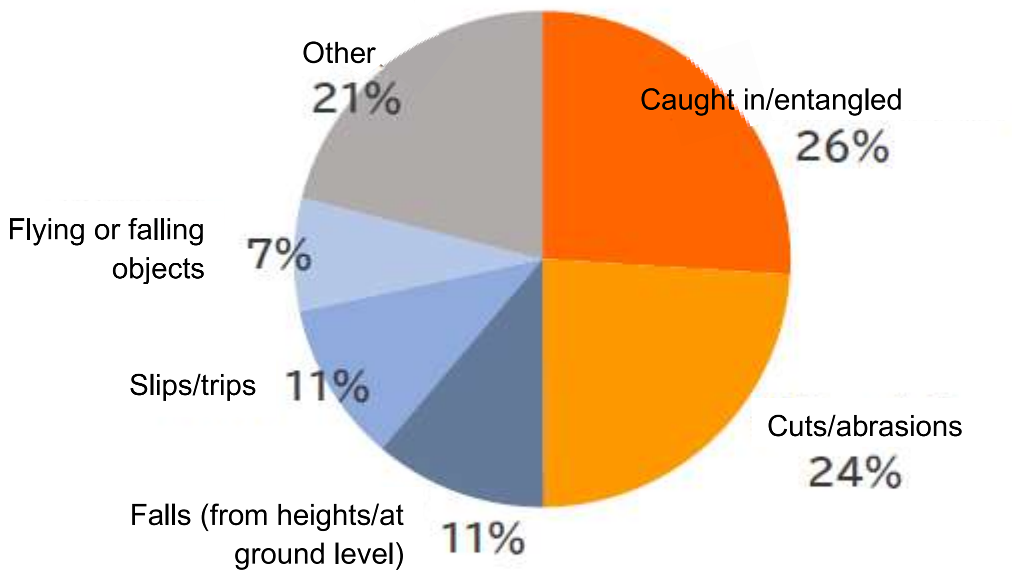


Figure 1-9: Injuries and Fatalities by Accident Type in the Lumber Industry (2019–2023)

(2) Appropriate Clothing for Safety

To work safely, it is necessary to choose clothing that matches the type of work and the season. Workers must wear work clothing with sleeves and hems that fit snugly.

In particular, when performing tasks where there is a risk of being caught in rotating parts such as saw blades or rollers, workers must pay attention to loose clothing and strings, and must not wear gloves, aprons, or towels.

In addition to helmets and work caps, it is also essential to correctly wear protective equipment appropriate for the task, such as safety glasses, masks, safety shoes, and earplugs.

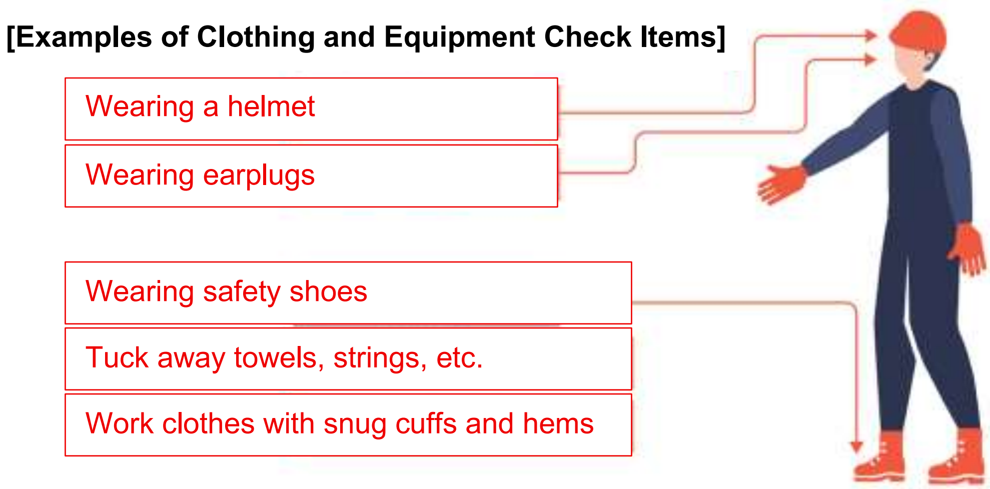


Figure 1-10: Key Points of Appropriate Clothing for Safety

(3) Risk Assessment

Risk assessment is the process of identifying hazardous areas or conditions in the workplace, evaluating the level of risk and priority by considering both the potential severity of an accident and the likelihood of its occurrence, and then examining measures to reduce those risks starting with the highest priority.

Conducting a risk assessment not only clarifies the risks present in the workplace but also helps workers recognize and share awareness of those risks.

(4) Principles of Machine Safety Devices

Machine safety devices and equipment are designed based on two different concepts: “fool-proof” and “fail-safe.”

Table: Principles of Machine Safety Devices

Fool-proof	This is a design concept based on the recognition that humans are prone to making mistakes. Examples include covering the rotating parts of a machine to prevent human contact, or using an interlock that cuts off the electrical circuit when the cover of a moving part is opened for maintenance or repair.
Fail-safe	This design concept ensures that, even if an abnormality or failure, the system operates safely, preventing accidents or disasters and maintaining the overall safety of the machine.

Woodworking machines are equipped with various safety devices, such as covers for rotating parts, guards to prevent contact with blades, devices to stop materials from scattering or rebounding, and interlock mechanisms that prevent the machine from operating during inspection or repair.

These safety devices are essential for protecting workers from occupational accidents, so they must never be removed when using the machine.

(5) Machine and Tool Inspection

When defects occur in machines or blades, accidents are more likely to happen. Therefore, it is important to carry out proper inspections and maintenance before using machines and regularly to prevent malfunctions.

If an inspection reveals an abnormality in the machine, it must be adjusted or repaired immediately.

In addition, when inspecting, maintaining, or cleaning a machine, always turn off the power to prevent the machine from suddenly starting up, and ensure that it is completely stopped.

(6) 4S Activities

4S activities refer to the daily practice of Seiri (Sorting), Seiton (Setting in order), Seiketsu (Cleanliness), and Seisou (Cleaning).

In workplaces where 4S activities are not properly implemented, objects may be left in inappropriate places, making it difficult to secure sufficient working space and increasing the risk of contact accidents. In addition, when wood chips, offcuts, or bark remain on the floor, the risk of tripping and falling accidents also increases.

Therefore, it is important to carry out 4S activities as part of daily routines—such as preparation before work and tidying up after work—to reduce the risk of accidents.

Chapter 2: Products and Their Uses

2.1 Lumber

Most lumber is used as construction materials such as columns, foundations, and beams. It is also used for packaging materials, civil engineering and construction materials, as well as for furniture and fittings.

Under the JAS (Japanese Agricultural Standards), lumber is classified into the following categories: “Non-structural Lumber,” “Visually Rated Structural Lumber,” “Machine Stress Rated Structural Lumber,” “Lumber Wood for Backing Material,” and “Hardwood Lumber.”

Lumber is further divided into three types according to the shape of its cross-section.

Table: Types of Lumber

Boards	Lumber in which the short side of the cross-section is less than 75 mm, and the long side of the cross-section is at least four times the length of the short side
Squares	- Lumber in which the short side of the cross-section is 75 mm or more - Lumber in which the short side of the cross-section is less than 75 mm, and the long side of the cross-section is less than four times the length of the short side
Round lumber (for structural use only)	Lumber with a circular cross-section and a constant diameter along its length

The following section explains the JAS standards for lumber.

(1) Non-structural Lumber

This is made from softwood and used for sills, lintels, walls, and other interior parts of buildings.

(2) Structural Softwood Lumber

This is made from softwood and used for the main structural load-bearing parts of buildings. There are two standards for structural softwood lumber: visually rated structural softwood lumber, which is graded by visually inspecting defects such as knots; and machine stress-rated structural softwood lumber, which is graded by measuring the Young’s modulus using machines.

Visually graded structural lumber is further divided into Type A structural lumber, used for members such as girders that require high bending performance, and Type B structural lumber, used for members such as columns that require compressive strength. It is classified into three grades (1, 2, and 3) based on factors such as knot size, cracks, and warping.

Machine stress-rated structural softwood lumber is graded by individually measuring the Young's modulus in bending of each piece with a grading machine. It is classified into six grades: E50, E70, E90, E110, E130, and E150. The higher the value, the greater the bending strength.

(3) Sawn Lumber for Backing Material

This refers to lumber made from softwood that is used as substructure material in roofs, floors, walls, and other parts of buildings that are not visible from the outside.

(4) Hardwood Lumber

This refers to lumber made from hardwood.

In addition to the classifications under JAS standards, the following types of lumber are also recognized in general commercial practice:

(1) Small structural members	A collective term for small-section lumber such as rafters, nuki (tie beams), and sheathing boards
(2) Itawari (standard-width boards)	Among board products, lumber corresponding to thick boards
(3) Small-section lumber	A collective term for square lumber with cross-sections smaller than rafters
(4) Half-round lumber	Lumber with two opposite sides of the log sawn parallel, used for floor joists and roof beams
(5) Half-sawn, two-sawn, and three-sawn lumber	Square lumber cut to half or one-third of its thickness, typically used for braces, studs, and lintels
(6) Large square, medium square, and small square lumber	In imported square lumber, pieces less than 5 inches are called small squares, those from 5 to 16 inches are called medium squares, and those 18 inches or larger are called large squares

2.2 Laminated Wood

Because laminated wood is made using dried laminas, it is characterized by high dimensional accuracy and stability. Another major feature is that defects such as knots are removed during production, resulting in less variation in strength performance and greater consistency.

Furthermore, laminated wood can be manufactured by bonding laminas together freely in the width, thickness, and length directions. This provides a high degree of freedom in size and shape, making it possible to produce long and large laminated wood as well as curved laminated wood, such as arches.

Figure 2-1: Examples of Laminated Wood Applications

Figure 2-2 Applications of Laminated Wood (Curved Members)

Photo: "Laminated Wood," Japan Laminated Wood Products Association

【Glossary】

Lamina: A basic unit of glued laminated wood, usually a sawn board such as lumber or small square lumber. It can also refer to boards that are joined together in the width or length direction.

(1) Structural Laminated Wood

Structural laminated wood is used as load-bearing members of buildings, such as columns, beams, and sills.

Under the JAS standards, the classification is according to the cross-sectional size.

Large cross-section: With a short side of 15 cm or more and a cross-sectional area of 300 cm^2 or more

Medium cross-section: With a short side of 7.5 cm or more and a long side of 15 cm or more (excluding large cross-sections)

Small cross-section: With a short side of less than 7.5 cm or a long side of less than 15 cm

Figure 2-3: Medium Cross-section Laminated Wood (Beams and Girders)

Figure 2-4: Small Cross-section Laminated Wood (Columns and Sills)

Photo: "Laminated Wood," Japan Laminated Wood Products Association

Among these, small- and medium-sized cross-section laminated wood is used in houses, while large cross-section laminated wood is used in non-residential wooden buildings such as gymnasiums and commercial facilities.

The strength performance of structural laminated wood is indicated by the strength grade specified in the JAS standards, shown as "E○○○-F△△△." Here, E represents the Young's modulus in bending, and F represents the bending strength. The larger the numbers ○○○ and △△△, the higher the strength performance.

In addition, there are "decorative laminated structural columns," which have a decorative veneer attached to the surface for appearance. These are mainly used as columns in Japanese-style rooms of houses.

(2) Non-structural Laminated Wood

Non-structural laminated wood has an attractive appearance, used for interior fittings of buildings and for furniture. When a decorative veneer is attached to the surface of non-structural laminated wood, it is called “decorative non-structural laminated wood.”

Both non-structural laminated wood and decorative non-structural laminated wood may also have surface decorations such as grooves.

Figure 2-5: Examples of Non-Structural Laminated Wood Applications

Photo: “Laminated Wood,” Japan Laminated Wood Products Association

2.3 Plywood

Plywood has features such as providing a large surface area, having little expansion and shrinkage (high dimensional stability), and offering strength as a panel. Its applications are wide-ranging, from housing and building uses to daily life items such as musical instruments, sporting goods, and furniture, as well as vehicles such as interior materials for railway cars and truck beds.

In the JAS standards, types such as "ordinary plywood," "plywood for concrete formwork," and "structural plywood" are specified according to their use.

(1) Ordinary Plywood

This is the type of plywood widely used for general purposes such as furniture and wood products. Hardwood species such as lauan and shina are mainly used as raw materials.

The common size is 910 mm × 1820 mm, which is also called "3 × 6 ('saburoku')" in Japan. The thickness varies depending on the application, and thinner sheets are called thin plywood.

Figure 2-6: Examples of Ordinary Plywood Applications (Conference Table)

Figure 2-7: Examples of Ordinary Plywood Applications (Election Poster Board)

(2) Plywood for Concrete Formwork

This has sufficient strength and water resistance and is widely used as formwork for pouring and molding concrete at construction and civil engineering sites.

Some types are finished with coatings or surface treatments that prevent concrete from sticking, so that the concrete surface becomes smooth after placement.


Figure 2-8: Plywood for Concrete Formwork

Photo: Website of Japan Plywood Manufacturers' Association

(3) Structural Plywood

This refers to plywood used in important structural parts of buildings. It is mainly used as base material for walls, floors, and roofs. Domestic softwood is often used as raw material.

The size is the same as ordinary plywood, with the "3 × 6 'saburoku'" size the most common. Thickness generally ranges from 9 mm or 12 mm for walls to 12–28 mm for floors. In particular, 24 mm and 28 mm products are called "thick structural plywood," which are becoming popular because they allow the omission of floor joists.

In the JAS standards, grades 1 and 2 are specified according to the type of strength test, and special grade (Tokurui) and type 1 are specified according to bonding performance. In practice, grade 2 with special bonding performance (Tokurui) is commonly used for wall, floor, and roof base materials.


Figure 2-9: Examples of Structural Plywood Applications

Photo: Website of Japan Plywood Manufacturers' Association

2.4 LVL (Laminated Veneer Lumber)

LVL is made by laminating several to dozens of veneer sheets, each 2–4 mm thick. Compared with plywood, many LVL products are thicker and are often used as structural members.

Its features include consistent strength with little variation, high dimensional flexibility, and the ability to produce long or wide members.

In the JAS standards, there are two types depending on use: “structural laminated veneer lumber” and “non-structural laminated veneer lumber.”

(1) Structural Laminated Veneer Lumber

This refers to products mainly used as load-bearing members of structures.

Those without cross-laminated veneer sheets, or with cross-laminated veneers only in the second layer from the surface, are called “Type A structural LVL.” All others are called “Type B structural LVL.”

Figure 2-10: Structural Laminated Veneer Lumber (LVL)

Photo: Website of National LVL Association

Type B structural LVL has detailed rules for the placement of cross-laminated veneer sheets, providing higher dimensional stability and making it usable as a panel material.

Figure 2-11: Examples of Structural LVL Applications (Beams)

Figure 2-12: Examples of Structural LVL Applications (Roof Trusses) (Kosuge Village Gymnasium)

Photo: Website of National LVL Association

(2) Non-structural Laminated Veneer Lumber

This refers to non-structural materials mainly used as base materials for furniture and fittings, or for interior finishing of buildings.

Figure 2-13: Examples of Non-structural LVL Applications (Hatoba Kitchen – Use of Laminated Surface)

Figure 2-14: Examples of Non-structural LVL Applications (Exhibition Booth – Use of Laminated Surface)

Photo: Website of National LVL Association

2.5 Veneer

Veneer is a type of thin wood sheet used for surface decoration in furniture, fittings, and interior finishes of buildings. It is also called "decorative veneer."

It is rarely used in its raw form; instead, it is bonded to various base materials to make finished products. Depending on the application, different base materials are used as follows.

(1) Wood-based Materials

Veneer is commonly applied to smooth-surfaced wood materials such as lauan plywood, MDF (medium density fiberboard), to other materials, it has a longer history of use. The main uses are in furniture, joinery, and general interior decoration.

Figure 2-15

(2) Metal Sheet

This material is produced by bonding veneer to a metal sheet with a fibrous sheet in between, using a special adhesive. It offers excellent dimensional stability, shape stability, and moldability. Some types are used as non-combustible (fire-resistant) interior materials, not only for building interiors but also for applications such as elevators and railway car interiors.

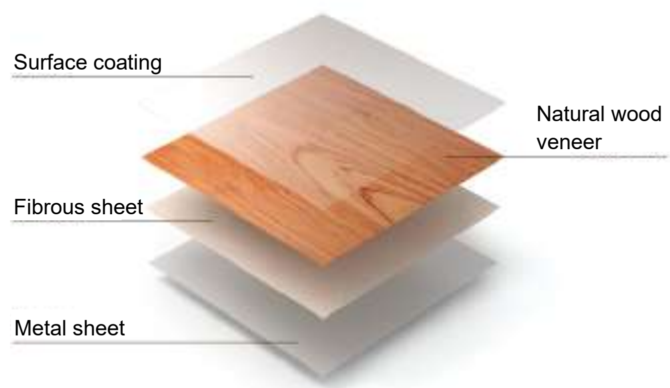


Figure 2-16

(3) Glass

This material is made by bonding veneer covered with flat glass, which highlights the wood grain clearly and provides excellent translucency and durability. The main applications are interior wall surfaces, furniture, and lighting fixtures.

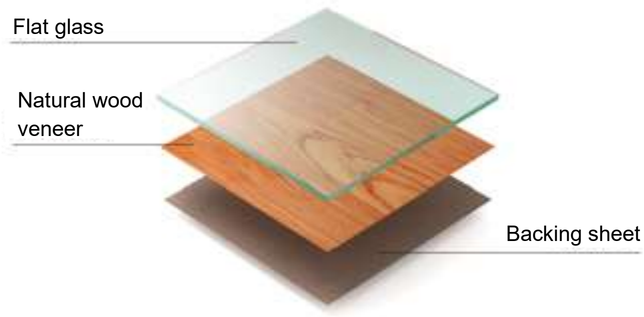


Figure 2-17

(4) Nonwoven Fabric and Washi (Traditional Japanese Paper), etc.

This material is made by attaching veneer to nonwoven fabric or washi, which increases the strength of the veneer and makes it more resistant to tearing and splitting. It can be applied to various materials afterward.
It is highly flexible and features well-suited curved surface processing.

The main applications include housing components, furniture, decorative items, and automobile interiors, among others.

Figure 2-18

(5) Non-flammable Board

This material is made by bonding veneer to non-combustible base materials such as volcanic glass-based composite boards and fiber-reinforced cement boards. It can be used as an interior wall surface even in spaces subject to interior finish restrictions under the Building Standards Act.

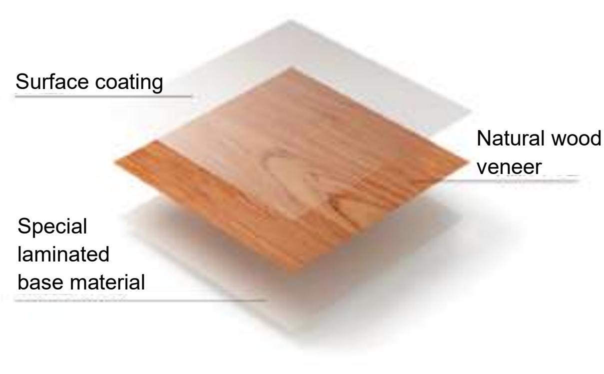


Figure 2-19

2.6 Flooring

Under the JAS standards, there are two types of flooring: "solid flooring" and "engineered flooring." Flooring that uses lumber as the base material and has only one structural layer in the thickness direction is called solid flooring, while all others are referred to as engineered flooring.

(1) Solid Flooring

A characteristic of solid flooring is that it can be used for a long time by performing maintenance such as sanding and re-coating as the surface deteriorates over time. It is used not only in houses but also in educational facilities such as schools and gymnasiums, as well as in commercial facilities.

Figure 2-20: Examples of Solid Flooring Applications

Photo: "Flooring Guide" by the Japan Flooring Association

Solid flooring includes several types, such as flooring boards made by using lumber as the base material and forming it into boards, flooring blocks made by joining two or more pieces of lumber side by side, and mosaic parquet, which is made by arranging two or more small pieces of lumber not exceeding 22.5 cm on the longest side and combining them with paper or other materials.

Figure 2-21: Flooring Board

Figure 2-22: Flooring Block

Figure 2-23: Mosaic Parquet

(2) Engineered Flooring

Engineered flooring refers to all types of flooring other than solid flooring. A variety of products are available depending on the combination of the base material and surface decorative materials used in engineered flooring. In Japan, a major type of composite flooring produced is made by using plywood as the base material, attaching MDF on top of it, and then applying a decorative surface with natural wood veneer or an olefin sheet.

Engineered flooring is less prone to deformation caused by moisture and has excellent dimensional stability. In addition, since engineered flooring is generally less expensive than solid flooring, it is widely used in houses, condominiums, and offices.

Figure 2-24: Engineered Flooring with Softwood Plywood as the Base Material

2.7 Wood Chips

The applications of wood chips vary depending on their raw materials.

Wood chips made from factory residues such as logs and sawmill byproducts, as well as forest residues, are mainly used for papermaking and as fuel. On the other hand, wood chips made from demolition wood from houses and other waste materials are used as boiler fuel and as raw material for wood-based boards.

(1) Raw Material for Papermaking

In paper mills, they are used as raw material for pulping in the production of paper.

(2) Raw Material for Boards

In wood-based board factories, they serve as raw material for fiberboard and particleboard.

(3) For Fuel

They are used as fuel in wood biomass power plants. In recent years, the operation of woody biomass power plants in Japan has been increasing as a renewable energy source, and the demand for chips for fuel has also been increasing.

(4) Other Uses

When spread on the ground, they provide excellent cushioning and are therefore used as mulch material in gardening, on walkways in parks, and on training tracks for racehorses.

2.8 Pre-cutting

Use of pre-cut lumber has been spreading because it offers several advantages: design information of a building is converted into wood processing data, and the wood is processed in factories using computer-controlled machines before being delivered to the construction site. This ensures a stable supply of high-precision, high-quality components, shortens the construction period on-site, and reduces waste such as wood chips at the construction site.

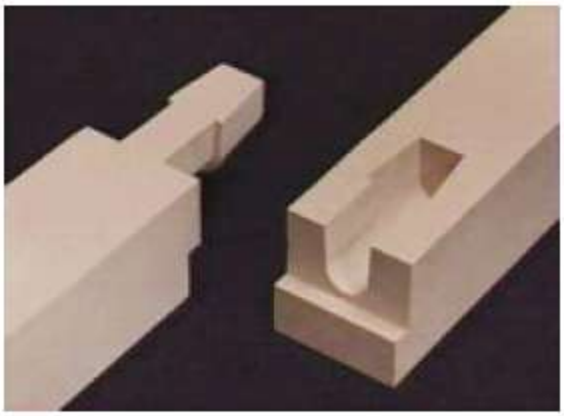


Figure 2-25: Pre-cut Lumber

Figure 2-26: Construction Site Assembling Pre-cut Lumber

Photo: Japan Pre-cut Association for Wooden Houses

Chapter 3: Manufacturing Processes of Each Product

3.1 Sawmilling

The sawmilling process varies greatly depending on the scale of the sawmill, the types of logs used, and the types of lumber products being produced, but in general, it is carried out through the following steps.

(1) Debarking

Debarking refers to the process of removing bark from logs. It is carried out for the following reasons: (1) to prevent saw blades from being damaged by bark or soil attached to the bark, (2) to make log cutting easier, and (3) to avoid mixing bark when producing chips from residues. Debarking is done using a machine called a barker.

(2) Log Breakdown

"Log breakdown" refers to determining from which part of the log and into what type of lumber products it will be sawn, and then sawing the log accordingly.

Since log breakdown greatly affects the yield (the ratio of the volume of lumber produced to the volume of logs used) and the value of the lumber products, it is one of the most important operations.

Log breakdown is carried out with consideration of the diameter and quality of the logs, as well as the required dimensions and quality of the lumber products. The method also varies depending on the tree species being sawn and the region.

(3) Sawmilling

It is the main process of sawmilling. Sawing logs into semi-finished products such as flitches is called "primary breakdown." Sawing those semi-finished products into smaller semi-finished products or products is called "secondary breakdown," and sawing the secondary semi-finished products into final products is called "tertiary breakdown." In practice, however, primary, secondary, and tertiary breakdowns are often not clearly distinguished. All these operations are carried out using machines such as band saws with automatic log carriages, twin band saws with carriages, and twin circular saws with carriages.

In addition, trimming off the rounded edges of waney boards (boards that retain the round outer surface of the log) to determine the product's width is called edging, while cutting to length is called cross-cutting. These processes are also part of sawmilling. Edging is done using machines called edgers, while cross-cutting is performed with machines such as trimmers or cross cut-off saws.

(4) Drying

Wood with a high moisture content will shrink as it dries over time, causing changes in dimension, warping, or cracking. Therefore, it is necessary to remove moisture in advance so that the wood reaches a moisture content suitable for the environment in which it will be used.

There are two methods of drying wood: natural drying and artificial drying.

- Natural Drying

Air drying is a method in which lumber is stacked outdoors with spacers and dried using solar heat and wind. Lumber is stacked with spacers in a well-ventilated, well-drained location, oriented perpendicular to the prevailing wind direction. In addition, roofing is always provided to protect the lumber from direct sunlight, rain, and dew.

Since the drying period is long, this method is not suitable for lumber that tends to easily crack, become moldy, or decay.

- Artificial Drying

Artificial drying is a method in which lumber is dried in a kiln while controlling conditions such as temperature, humidity, and pressure. The method of varying temperature and humidity to reduce drying defects, such as cracking, and to speed up the drying process is called the drying schedule, which is determined according to factors such as the tree species and board thickness.

Various types of kilns are used for artificial drying, including steam-heated kilns, dehumidification kilns, combined steam-heated and high-frequency kilns, and steam-heated vacuum kilns. Among these, steam-heated kilns are the most common.

(5) Sorting, Bundling, and Shipping

"Sorting" refers to the process of classifying lumber products by dimensions, grades, and intended uses. "Bundling" refers to packaging lumber products of the same dimensions and grade together using banding straps or similar materials. These operations are carried out using machines such as automatic sorters and bundling machines.

Lumber products that have been sorted and bundled are packaged with materials such as plastic to protect them from moisture, dirt, and damage before shipping.

3.2 Laminated Wood

As specified in the JAS standards, there are four types of laminated wood, as explained in 2.2: structural laminated wood, decorative laminated structural columns, non-structural laminated wood, and decorative non-structural laminated wood.

Although the manufacturing process varies by type, this text primarily focuses on the manufacturing process of structural laminated wood.

(1) Raw Materials

The lumber used as a raw material for laminated wood is called laminas.

About half of the laminated wood produced in Japan is manufactured using pre-dried laminas imported from overseas, mainly from Europe. In addition, there are laminated wood factories that manufacture laminated wood using laminas sawn from logs in their own mills.

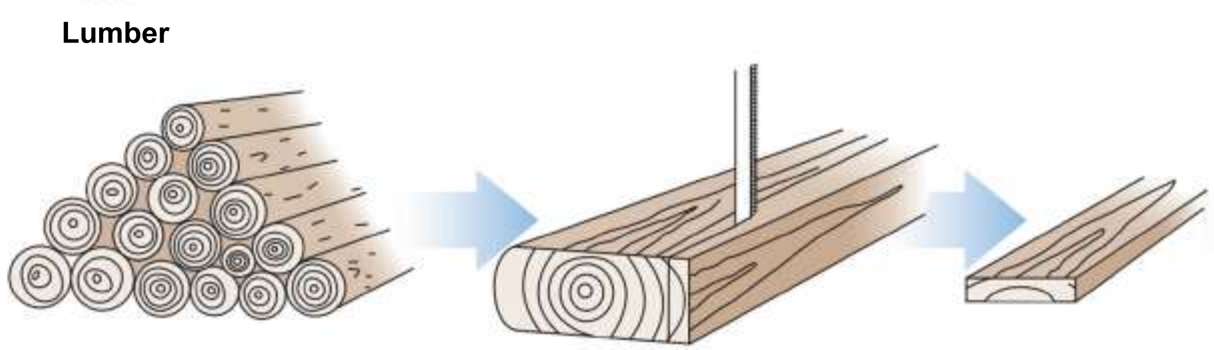


Figure 3-1: Manufacturing of Laminated Wood Lamina

(2) Moisture Content Inspection and Preliminary Cutting

Since laminated wood requires the use of sufficiently dried laminas (with a moisture content of 15% or less), the moisture content of the laminas are measured using devices such as microwave moisture meters. Laminas that have met the moisture content standard are sized using a molder.

(3) Grading

Laminas are sorted by quality (strength grade) through either visual inspection or mechanical grading. This process is called grading, and in general, grading is based on the Young's modulus of the lamina measured with a grading machine (stress grading machine).

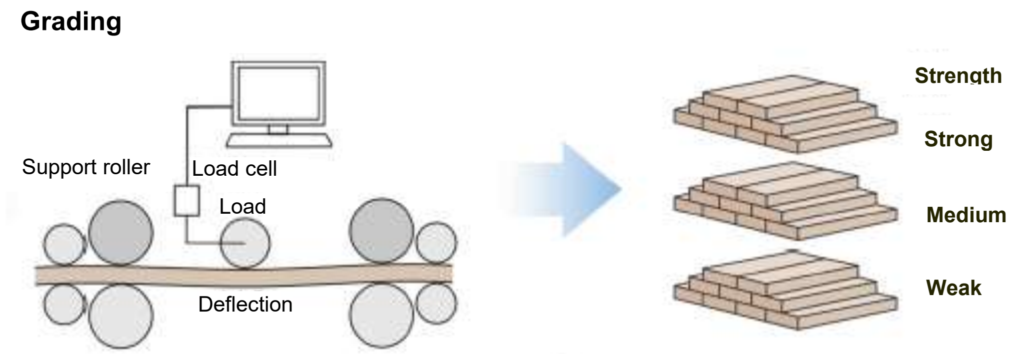


Figure 3-2: Grading of Laminas

(4) Lengthwise Jointing and Edge Jointing of Laminas

If a lamina contains major defects such as large knots or damage, those parts are removed. Shortened lamina pieces are lengthwise jointed with others of the same quality (strength grade) to improve yield, and then adjusted to the specified length to match the laminated wood product being manufactured. This process is called lengthwise jointing, and in laminated wood manufacturing, the finger joint method is mainly used.

If laminas are not wide enough for the required width of the laminated wood product being manufactured, they are glued together in the width direction. This is called edge jointing.

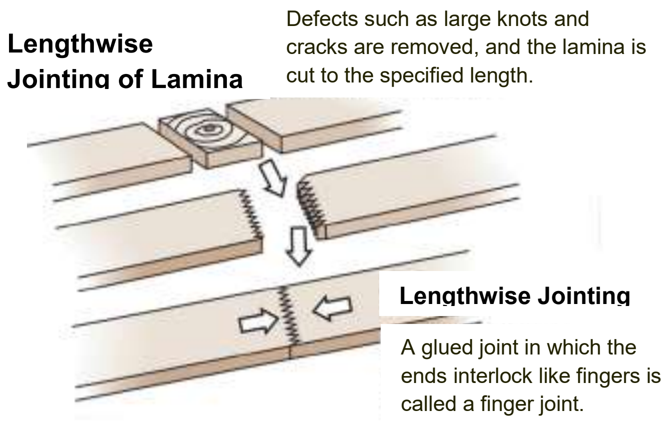


Figure 3-3: Lengthwise Jointing of Lamina

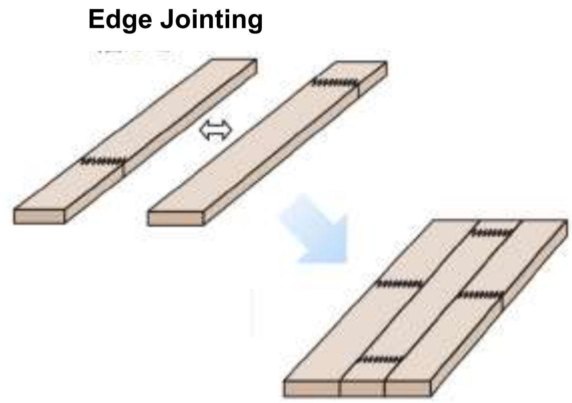


Figure 3-4: Edge Jointing of Lamina

(5) Cutting of Laminas

Laminas sorted by quality are smoothed with a planer or similar equipment to prepare them for lamination and bonding.

(6) Lay-up

The process of combining laminas sorted by quality to ensure the required strength is called lay-up. At this stage, when finger-jointed laminas are placed next to each other, their joints must be staggered so that the distance between them is at least 15 cm.

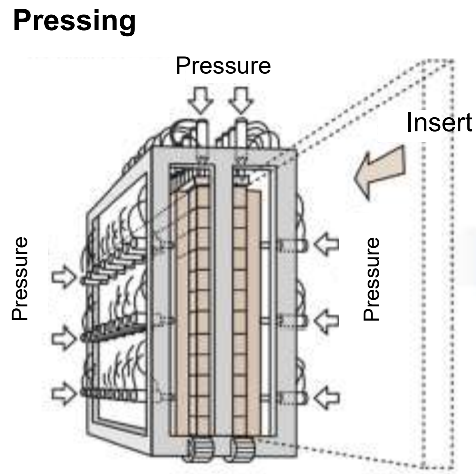
Laminated wood manufactured by combining laminas of the same species and quality is called laminated wood with homogeneous grading, while laminated wood manufactured by combining laminas of different qualities is called laminated wood with heterogeneous grading. Laminated wood with heterogeneous grading is often used for beams and girders, with laminas of higher Young's modulus placed on the outside and those of lower Young's modulus on the inside.

The lay-up process may be performed automatically by machines or manually by workers, depending on the factory.

(7) Lamination and Bonding

After the adhesive is applied to the surface of the lamina, multiple laminas are stacked together and bonded under pressure. This is called lamination and bonding.

The type of adhesive used varies depending on the service environment (application) of the laminated wood, but mainly water-based polymer isocyanate adhesives and resorcinol resin adhesives are used.



Pressing of laminated wood by cold press

Figure 3-5: Pressing of Laminated Wood (Pressing)

(8) Finishing and Inspection

All four surfaces of the bonded laminated wood are planed to adjust the dimensions. The appearance is inspected visually, and any knot holes are filled with synthetic resin or other materials.

3.3 Plywood and LVL

Although the manufacturing methods of plywood and LVL differ, they are similar in that both are made by laminating veneer sheets. Therefore, this text mainly explains the manufacturing process of plywood.

(1) Log Processing

The bark of the logs is removed with a barker, and the logs are cut to the required length if necessary. They are then steamed in a steaming chamber to make them easier to cut.

At this stage, it is checked whether any metal or other objects that could interfere with cutting are attached to the logs, and if so, they are removed.

Figure 3-6: Log Processing for Plywood

(2) Cutting

In the manufacturing of plywood and LVL, a rotary veneer lathe is generally used to cut veneer sheets. After the rotational center of the log is set with a centering device (log charger), the log is cut with a rotary veneer lathe into veneer sheets 0.6–5.0 mm thick.

The cut veneer sheets are trimmed with a veneer clipper to remove defects such as knots and cracks and are cut to a uniform length.

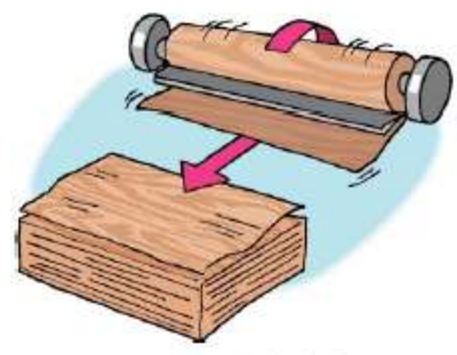


Figure 3-7: Cutting of Veneer Sheets

(3) Drying of Veneer Sheets

The cut veneer sheets contain a high amount of moisture (called "green veneer sheets"), and since they cannot be bonded properly in this state, they are dried in a dryer to a moisture content of about 10%.

The drying temperature is raised to 160–180 °C according to the schedule, but is adjusted depending on the tree species and the season.

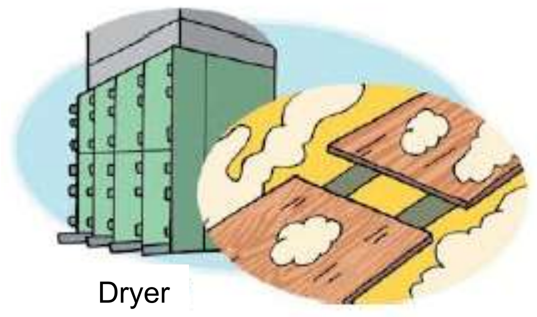


Figure 3-8: Drying of Veneer Sheets

(4) Veneer Preparation (Sorting, Repair, and Lay-up)

After drying, defects in the veneer sheets are repaired, and those that are too narrow are edge-jointed to adjust them to a uniform size.

The veneer sheets are sorted into those used for the surface (face), those used as core plies (center core, crossbands), and those used for the back. They are then combined in the specified number of plies with the grain direction arranged at right angles. This process is called lay-up.

In plywood factories, machines called veneer assembly equipment are introduced to perform the lay-up process automatically.

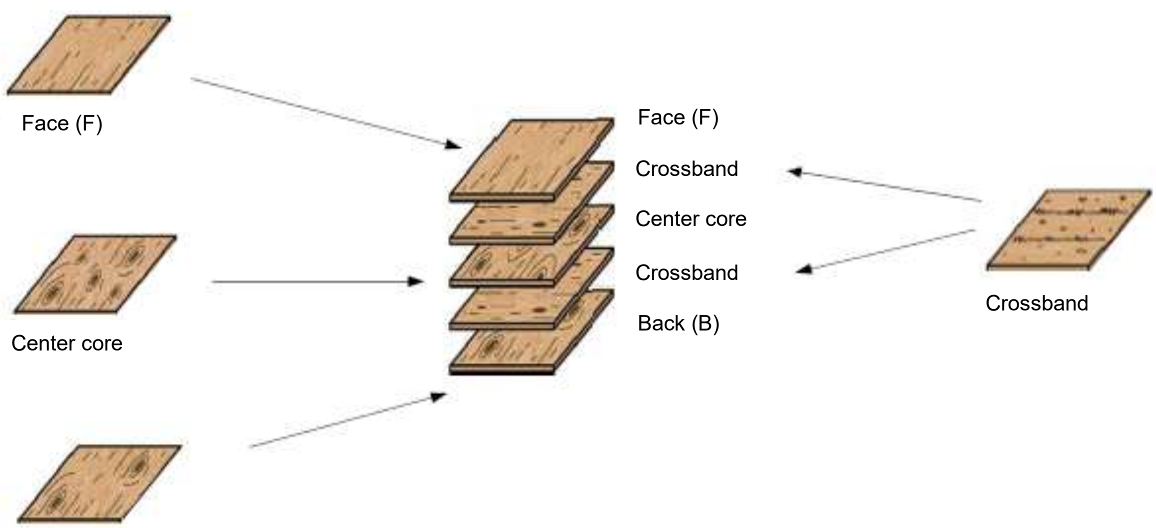


Figure 3-9: Plywood Lay-up

(5) Bonding

Adhesive is applied to both sides of the core veneers using a glue spreader or similar equipment, and they are laminated in the specified number of plies (3, 5, 7, etc., always an odd number).

The adhesive used varies depending on the application of the plywood. In general, phenolic resin adhesives are used for structural plywood, while melamine resin adhesives or urea resin adhesives are used for plywood intended for furniture and other non-structural applications.

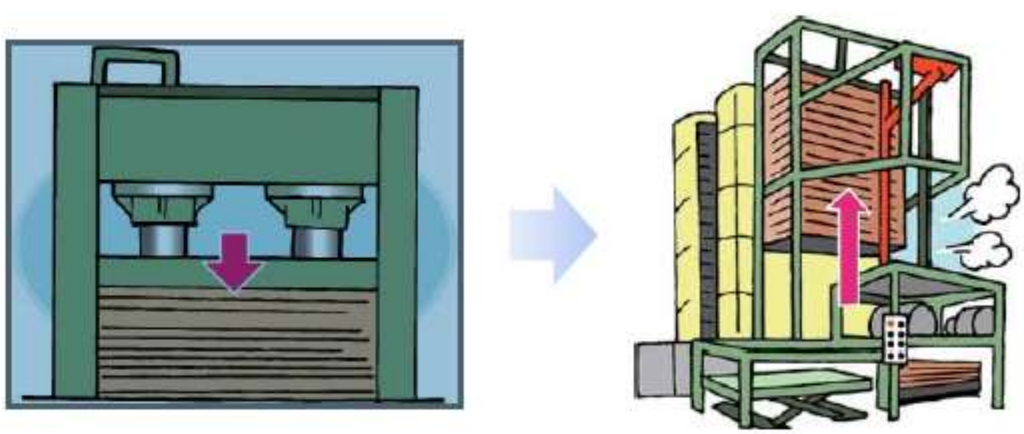
Figure 3-10: Bonding Process

(6) Cold Pressing and Hot Pressing

The freshly assembled plywood is given a preliminary press at room temperature using a cold-press machine (for about 20 minutes). This is called cold pressing.

After that, the plywood is hot-pressed at 110–135 °C under a pressure of 8–12 kgf/cm², using a hot press machine, to cure the adhesive and form the panel. This is called hot pressing.

After hot pressing, the panels are conditioned for a certain period (about 3–7 days) to stabilize bonding performance.



Cold Pressing

Hot Pressing

Figure 3-11: Pressing Process of Plywood

(7) Panel Trimming, Sanding Finish, and Inspection

Using a double sizer or similar equipment, all four edges of the plywood are trimmed to adjust it to the required dimensions.

After that, the surface is smoothed by sanding with a sander or planing with a planer, and each panel is shipped only after passing the required inspections.

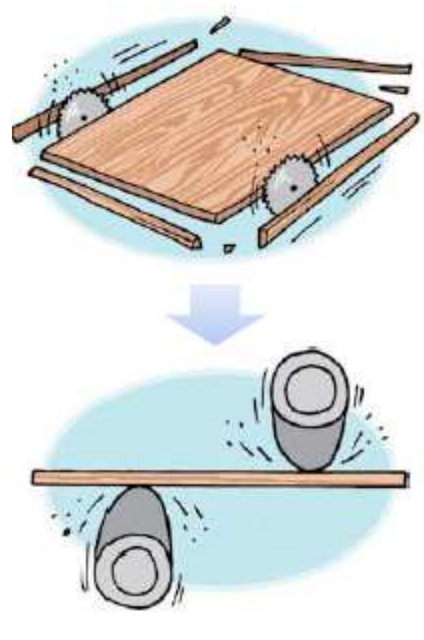


Figure 3-12: Finishing Process

3.4 Veneer

Logs used as raw material for veneer are selected high-quality timber that meet conditions such as large diameter, attractive grain, and good color and luster, and they are sourced not only from Japan but also from around the world.

3.4.1 Veneer Production

(1) Sawmilling

Logs for veneer are sawn at sawmills into blocks called “flitches.” At this stage, log breakdown is carried out while checking the condition of the logs—such as grain direction, knots, and the presence of defects—to ensure that veneers with beautiful grain can be obtained.

(2) Boiling

To soften the flitches to the proper hardness for slicing, they are boiled in hot water at 40–90 °C. The temperature and duration of boiling vary depending on the tree species and the condition of the wood.

In addition, boiling helps equalize the moisture content within the flitches and remove extractives, which is said to improve the color tone of the wood.

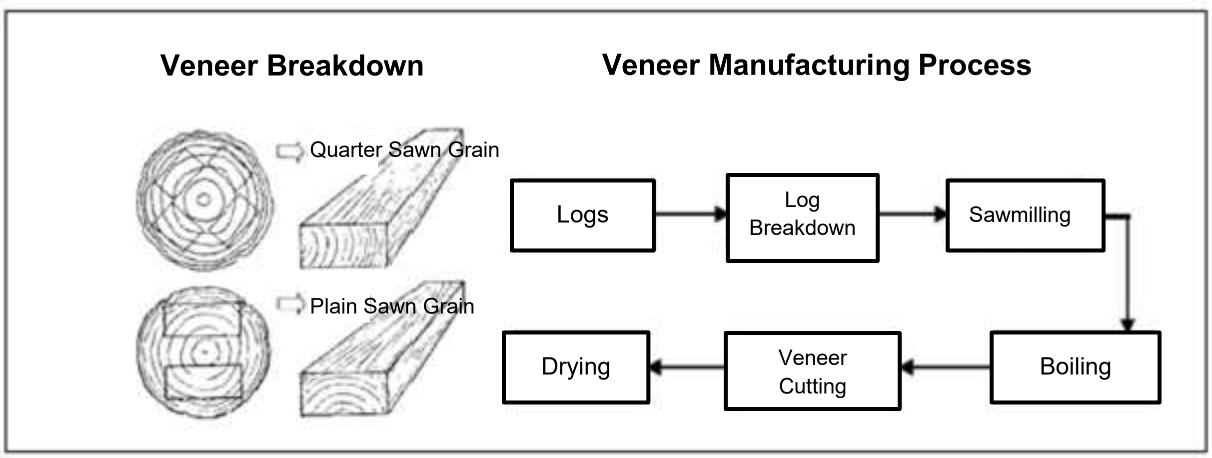


Figure 3-13: Veneer Production Process

(3) Cutting

The boiled flitches are sliced into veneers about 0.2–3.0 mm thick using a veneer slicer or a rotary lathe. In Japan, veneers with a thickness of about 0.2 mm are generally the standard.

The types of veneers produced vary by cutting method and include sliced veneer sheet, rotary-cut veneer sheet, and others. The most common type is sliced veneer sheet, produced with a veneer slicer, which is characterized by the ability to obtain desired grain patterns depending on the cutting method.

When sliced tangentially to the growth rings, plain-sawn veneers are produced; when sliced perpendicular to the growth rings, quarter-sawn veneers are produced.

In contrast, rotary-cut veneer sheet produced using a rotary lathe is characterized by its figured grain, in which the growth rings form irregular and complex patterns, and it allows for the production of continuous, wide sheets of veneer.

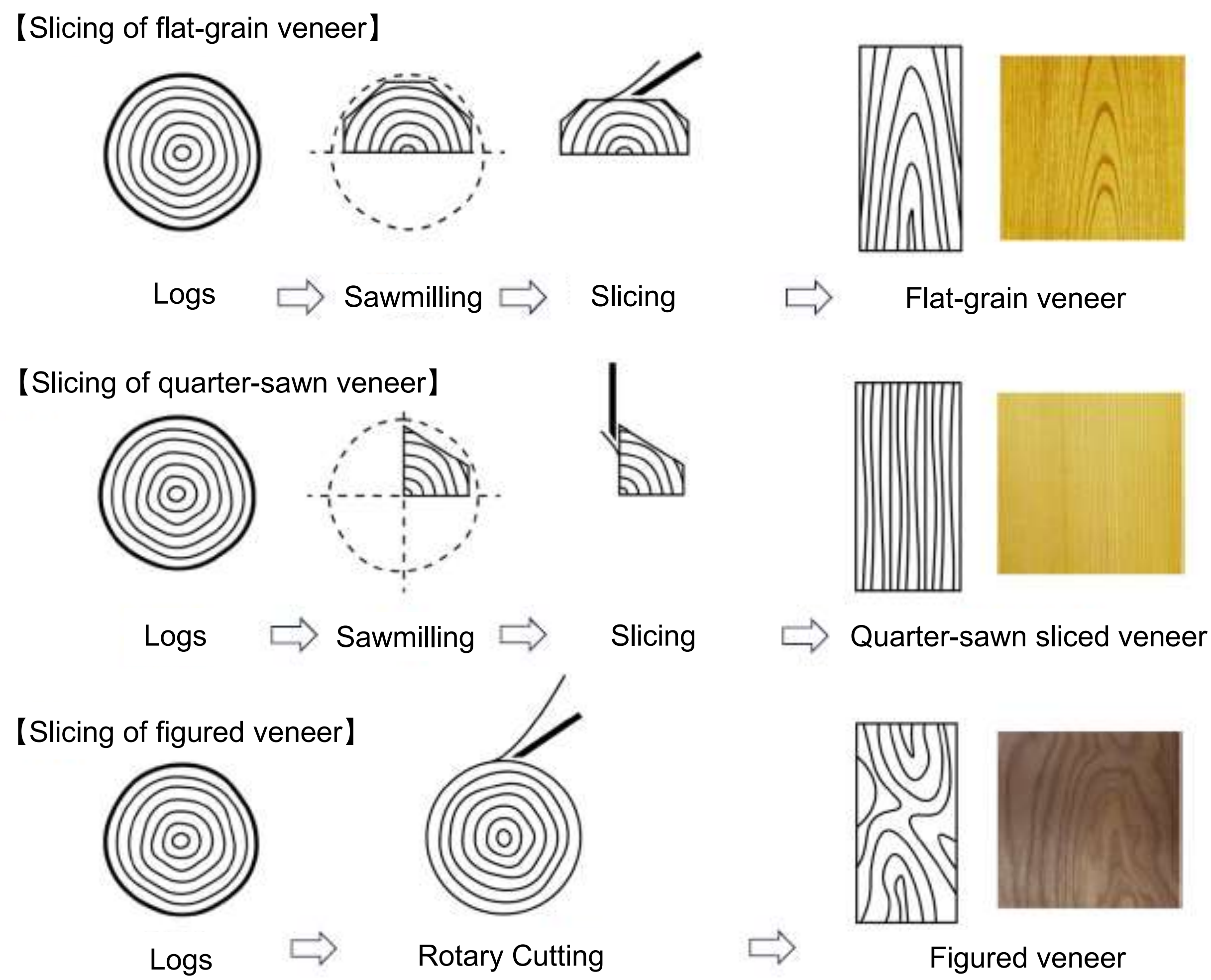


Figure 3-14: Methods of Slicing Veneer and Types of Wood Grain

(4) Drying

Thinly sliced veneer is dried to reduce its moisture content to an appropriate level, since if it remains damp it may develop mold or discoloration. Drying methods include air drying, hot-air drying, roller drying, and high-frequency drying, among which high-frequency drying is the most used.

3.4.2 Production of Veneer Products

The bonding of veneer is generally carried out manually, mainly by skilled workers. An adhesive is uniformly applied to the base material, and veneers cut to fit its width and the required number are carefully laid side by side, ensuring there are no overlaps or gaps.

Another characteristic is that various patterns can be created simply by changing the veneering arrangement. There are many such methods, including slip matching (straight matching), in which veneers of equal width are aligned in the same direction and placed side by side.

Slip matching
(Placed side by side in the same orientation)

Book matching
(Flipping every other sheet before matching)

Herringbone matching

Diamond matching

Reverse diamond matching

Figure 3-15: Examples of Veneer Matching Methods

3.5 Flooring

As explained in 2.6, there are two types of flooring: solid flooring and engineered flooring. Since the manufacturing process of flooring varies by product and manufacturer, this text focuses on the general manufacturing process of engineered flooring.

(1) Inspection and Adjustment of Plywood

It is common to use plywood with a thickness of about 9 mm as the base material for engineered flooring. First, the thickness and bonding condition of the incoming plywood are checked, and if necessary, the thickness is adjusted using a sander.

(2) Bonding with an MDF and a Veneer Sheet

On the surface of the plywood, an MDF layer about 3 mm thick is bonded, and on top of that, a natural wood veneer or an olefin sheet is attached with adhesive and pressed using a hot press.

The adhesives commonly used are polyurethane-based adhesives and epoxy resin-based adhesives.

(3) Dimension Cutting

The material bonded in step (2) is cut to the standard flooring size of 300 mm × 1800 mm using a circular saw or a band saw.

(4) Surface Processing

Since the surface grooves greatly influence the design of flooring, longitudinal grooves are processed on the surface to create the desired design. In some products, grooves are also cut in the lateral direction.

Machines such as routers and groove cutters are used for processing grooves.

(5) Tongue-and-Groove Processing

The sides of flooring boards are machined with a tongue-and-groove profile, which in Japanese is called “sa-ne.” This allows the flooring boards to be joined together during installation, preventing misalignment and movement.

The tongue-and-groove joint consists of a male part (tongue), formed by leaving a protrusion while trimming the top and bottom, and a female part (groove), created by cutting a recess to receive the tongue. These are machined on opposite sides of the flooring boards so that they fit together.

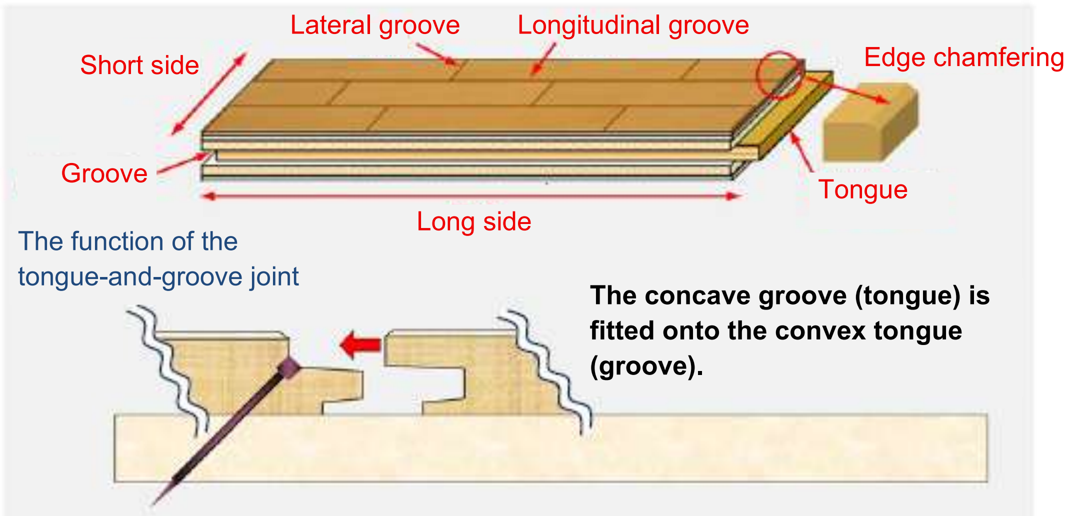


Figure 3-16: Example of Tongue-and-Groove Processing in Flooring

End tenoners and molders are used for tongue-and-groove processing.

(6) Staining and Coating

It is common for solid flooring and engineered flooring with natural wood veneer finishes to be stained and coated on the surface. (In the case of engineered flooring finished with an olefin sheet, no additional coating is applied since the olefin sheet is already pre-coated.)

For coating, machines such as roll coaters, which apply paint to the surface of automatically fed materials by rotating rollers, and flow coaters, which send materials through a curtain-like flow of paint, are used.

The paint is mixed with ultraviolet curing agents, and it is common practice to cure the coating film by exposing it to ultraviolet light.

3.6 Wood Chips

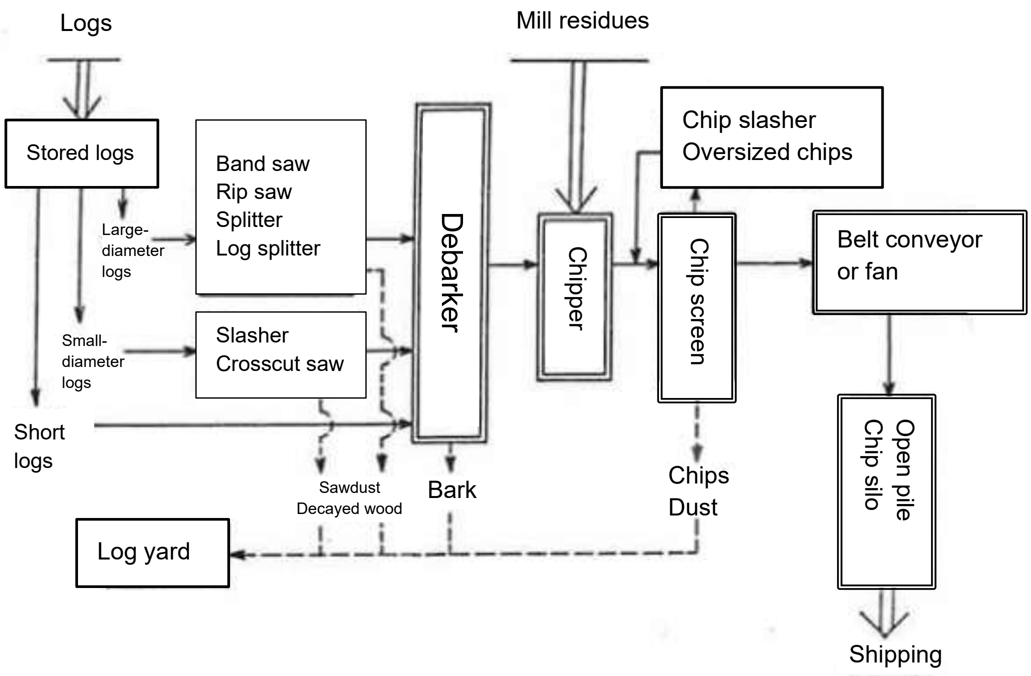


Figure 3-17: Typical Flow of Wood Chip Manufacturing Process

Source:" Wood Chips" by Pulpwood Communication Co., Ltd.

(1) Removal of Bark and Foreign Materials

When manufacturing chips from raw logs, it is common practice to use a debarker to remove the bark for papermaking chips, while fuel chips are generally produced without removing the bark.

When producing chips from demolition wood or waste materials from buildings and other structures, foreign objects such as rocks, concrete, and metal scraps, are identified and removed in advance before chipping. Such objects can damage the blades of crushers or chippers.

Small metal objects such as nails and bolts are removed after chipping using a magnetic separator.

(2) Cutting and Crushing

There are two main methods of producing wood chips.

Chips produced by cutting with chipper knives are called "cut chips," and their shape is a square, flake-like form.

In contrast, chips produced by mechanical impact using a hammer crusher are called "crushed chips," and their shape is elongated and pin-like. These are also referred to as pin chips or crusher chips.

Figure 3-18: Cut Chips

Figure 3-19: Crushed Chips

(3) Screening and Sorting

The manufactured chips are screened with a chip screen and sorted according to size.

(4) Storage

In wood chip factories, there are two main methods of chip storage: silo and open pile methods. When storing chips, care must be taken because microbial activity and other factors can cause the chips to generate heat, which may lead to spontaneous ignition.

In the case of the silo method, caution is required when entering a sealed chip silo. It is necessary to ensure adequate ventilation beforehand to prevent oxygen deficiency and inhalation of mold or dust.

3.7 Pre-cutting

At present, many pre-cut factories use CAD/CAM systems in which housing design information is entered into a computer, automatically converted into processing data for components, and then used to machine lumber under computer control.

(1) Raw Materials and Quality Inspection

In pre-cut processing, dimensional changes caused by the expansion and contraction of wood, as well as twisting or warping, can prevent joints and connections from fitting properly. For this reason, the use of dried lumber and laminated lumber has been increasing.

Since high-precision processing is required, inspections are carried out in advance to check the wood species, dimensions, defects such as cracks, twists, and bends, as well as moisture content.

(2) Input of Design Information (CAD Input)

CAD (Computer-Aided Design) refers to design support using computers. Housing design information is entered, and data necessary for processing components—such as the dimensions of each member and the shapes of joints and connections—are generated.

Figure 3-20: CAD Input

Photo: Japan Pre-cut Association for Wooden Houses

(3) Processing of Components

The data created with CAD are automatically converted into CAM (Computer-Aided Manufacturing) data, and the interconnected pre-cut processing machines perform the cutting and machining of the components. Since the processing machines are operated under computer control, the components are machined with an accuracy of less than 1 mm.

Figure 3-21: Cutting and Machining of Pre-cut Lumber

Photo: Japan Pre-cut Association for Wooden Houses

(4) Inspection, Packing, and Shipment

After the processed pre-cut components are inspected to confirm that they have been machined according to the data, they are packaged for each building, loaded onto trucks in the order in which they will be assembled at the construction site, and then shipped.

Figure 3-22: Inspection Work

Figure 3-23: Shipment with Packaging in Vinyl and Other Materials

Photo: Japan Pre-cut Association for Wooden Houses

Chapter 4 Main Machines and Equipment Used in the Manufacturing Processes of Each Product

4.1 Sawmilling

(1) Debarker (Bark Removing Machine)

A machine that removes bark from logs is called a debarker, and there are several types as follow.

- Ring Barker

Logs fed by chain drive are debarked by blades at the ends of arms attached to a rotating ring.

- Head Barker

Rotating blades mounted at the ends of arms are pressed against a rotating log to remove the bark.

- Chain Barker

A moving chain or chain cutter is pressed against a rotating log to remove the bark.

(2) Circular Saw Machine

A circular saw is a machine in which a disk-shaped saw blade is mounted on a main spindle (saw spindle) and rotated to cut wood. The main types follow.

- Twin Circular Saw Machine

This is a circular saw in which two saw blades are mounted on one or two spindles, allowing both ends (two parallel surfaces) of the lumber to be ripped simultaneously. There are types with automatic feed, types equipped with a feeding carriage, and types in which the lumber is fixed while the circular saw itself moves.

This is often used to saw square timbers from small-diameter logs.

- Edger

A circular saw used to trim off the wanes (rounded edges) of waney boards and saw them into boards of the required width. A circular saw in which one or two blades are mounted on spindles, with the lumber power-fed along a table for ripping.

There are single edgers with one circular saw blade, double edgers with two blades, and multiple edgers with three or more blades (also called gang edgers).

- Ripper (Rip Saw)

A circular saw equipped with caterpillar feeds or rollers for automatic feeding, used to rip lumber. Normally, the lumber is processed beneath the spindle.

In front of and behind the saw spindle, there are pressure rollers that prevent the workpiece from kicking back during cutting. By holding the material down against the table, they help ensure smooth feeding.

There are twin rippers with two circular saw blades, and multiple rippers with three or more blades (also called gang rippers).

- Cross Cut-off Saw

A circular saw used for cross-cutting lumber, in which the saw spindle moves in a direction perpendicular to its axis to cut across the grain. It is used for determining the length of sawn lumber and for cross-cutting back boards and offcuts.

- Trimmer

A circular saw, mainly using chains to feed the lumber crosswise, that performs cross-cutting with multiple saw blades. There are single-spindle trimmers, in which two or more circular saws are mounted on one spindle and the lumber is fed crosswise to cut it to length, and multiple-spindle trimmers, in which several circular saws, each with its own spindle, are arranged in parallel and operated simultaneously for cross-cutting.

(3) Band Saw Machine

A band saw is a machine in which an endless band saw blade is tensioned over two wheels, with one wheel driven to run the blade, and used for sawing lumber.

Band wheels can be arranged vertically or horizontally, called the vertical type and horizontal type, respectively. There are the following types of band saws.

- Band Saw Machine with Auto-feed Carriage

A band saw in which the lumber is placed on a carriage that reciprocates to perform ripping. It consists of the band saw body and an automatic log carriage. It is mainly used for primary and secondary breakdowns.

- Table Band Resaw

A band resaw equipped with a table and a fence, in which the lumber is fed along the table for ripping. It is used for secondary and tertiary breakdown of semi-finished lumber.

- Auto-roller Table Band Resaw

A band resaw equipped with an automatic roller device, in which feed rollers move the lumber along the table for ripping. A band resaw with two or more feed rollers is called a multiple automatic-feed table band resaw.

- Twin Band Saw Machine

A band resaw is a setup where two band saws with opposite hand configurations are installed facing each other, allowing the lumber to be ripped in two places simultaneously.

(4) Dust Collector

A machine that collects sawdust and fine dust generated during the sawing process by means of airflow.

Types include the cyclone type, which uses a blower to create suction and separates and collects sawdust by centrifugal force, and the bag filter type, which collects sawdust using filters.

4.2 Laminated Wood

(1) Stress Grading Machine

A machine that applies impact vibrations or loads to wood in order to measure its Young's modulus.

In the Japanese sawmilling industry, grading machines include the batch type, which applies a bending load to wood and determines the bending Young's modulus from the load and deformation; the continuous type, which applies a constant load while feeding the lumber along a production line and continuously measures the Young's modulus; and the impact vibration type, which strikes the wood to measure the unique frequency of longitudinal vibration and determines the dynamic Young's modulus.

Figure 4-1: Continuous Grading Machine

Figure 4-2: Recording the Calculated Young's Modulus of the Lamina into the Computer
Photo: First Wood Co., Ltd.

In laminated lumber factories, continuous grading machines are mainly used because they allow high-speed measurement. Different colored sprays can be applied to the sides of the lamina according to their grade classification, and the "lay-up" process is carried out based on these colors.

Figure 4-3: Inside a Continuous Grading Machine
Photo: Saito Wood Industry Co. Ltd.

(2) Finger-jointing Machine

- Finger Cutter

A finger-jointing machine is a machine that processes the end grain of laminas into a finger-like shape. By applying adhesive to the finger joints and joining them in the lengthwise direction, long laminas can be produced.

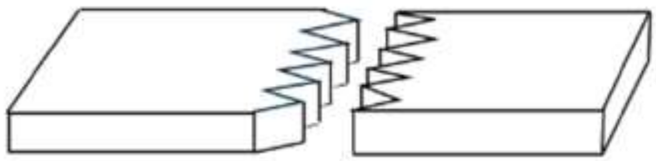


Figure 4-4: Finger Joint

Figure 4-5: Finger Cutter
Photo: Website of Kanefusa Corp.

Figure 4-6: Finger Joint
Photo: Website of Meiken Lamwood Corp.

(3) Press

This is a machine that applies adhesive and presses stacked laminas using hydraulic pressure or other means. It includes both rotary-type and vertical-type presses.

The pressing method varies depending on the type of adhesive used and the type of product being made (such as the cross-sectional size or whether it is straight or curved). Different machines are used accordingly.

The adhesives used for structural laminated wood are thermosetting, but bonding is also possible at room temperature. The bonding time (pressing time) varies depending on the type of adhesive.

For medium- and small-section laminated wood, aqueous polymer isocyanate adhesives are used. Cold-press machines, which apply pressure at room temperature, are used for pressing, and the required time is about 30–60 minutes.

For large-section laminated timber, resorcinol adhesives are mainly used. Cold-press machines are used for pressing under room-temperature conditions. In addition, for curved members in particular, a manual clamping method is used. The required time is about 12 hours in either case. In cold winter periods, it is necessary to warm the storage area for laminated wood during pressing.

In the case of resorcinol adhesives, some factories use a "high-frequency press," which applies pressure while heating with high frequency, in order to shorten the bonding time significantly. The required time is less than 30 minutes.

Figure 4-7: Vertical Cold Press for Medium-section Members

Figure 4-8: Rotary Cold Press for Small-section Members

Figure 4-9: Large Press for Large-section Members

Figure 4-10 Manual Pressing of Large-section Curved Members

Photo: Website of Meiken Lamwood Corp.

(4) Cutting Machines

For cutting the surfaces of raw laminas and laminated timber before shipment, planers and molders are used.

- Planer

This machine features rotating cutters that move along the wood, smoothing the surfaces of boards and square timbers. There are also machines that can plane the top, bottom, and both sides of the wood simultaneously.

Figure 4-11: Four-sided Planer
Photo: Website of Meiken Lamwood Corp.

- Molder

Like a planer, this machine features rotating cutters that run along the wood to cut the surfaces of boards and square timbers.

It can machine all four sides of the wood simultaneously, adjusting the thickness and width to precise dimensions. In addition, it can perform shaping, such as groove cutting, and add decorative patterns.

Figure 4-12: Molder
Photo: Website of Meiken Lamwood Corp.

4.3 Plywood, LVL, and Wood Veneer

(1) Veneer Manufacturing Machines

- Veneer Lathe

This machine produces thin veneer sheets continuously by pressing a blade against a rotating log. In plywood and LVL factories in Japan, a type of rotary lathe called the "spindle-less system," which was developed in Japan, is commonly used.

In the spindle-less system, rollers are placed to support the log from the side and bottom, while a serrated disk (called a gangi in Japanese) is pressed against the log. The rotation of the disk causes the log itself to rotate.

Because the log does not need to be held by a spindle, veneer sheets can still be peeled even when the core becomes small. This makes it possible to produce veneer sheets from logs with a minimum end diameter of about 14 cm.

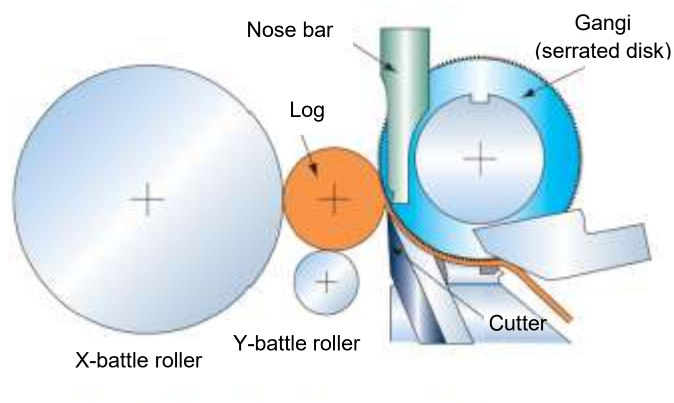


Figure 4-13: Mechanism of a Rotary Lathe (Spindle-less System)

- Veneer Slicer

This is a large plane-like machine that produces veneer by reciprocating a flitch or a blade. It consists of a plane bed with a blade, a feed mechanism, and a flitch holder (a device that grips the flitch).

Figure 4-14: Slicer

To achieve smooth cutting, the blade is generally set at an angle to the cutting direction of the flitch.

When the cutting direction is parallel to the grain direction of the flitch, the method is called "longitudinal slicing," and when it is perpendicular, the method is called "cross slicing." When processing thick veneers, the longitudinal slicing method is often used.

(2) Veneer Sheets Drying Machines

- Dryer

This machine continuously feeds veneer sheets between pairs of rollers and dries them by blowing hot air from a boiler. The hot air is forced to circulate either parallel or perpendicular to the feeding direction of the veneer sheet.

(3) Adhesive Application Machines

- Glue Spreader

This machine applies a controlled amount of adhesive to automatically fed veneer sheets using rotating rollers.

(4) Finishing Machines

- Double Sizer

This machine consists of two circular blades mounted in parallel with adjustable spacing, together with a wood feeding device.

It can cut both ends of plywood and similar materials simultaneously in a single feed, finishing them to the required dimensions. When the wood is fed manually, the machine is called a double saw.

- Sander

This machine grinds the surface of plywood and similar materials using abrasive paper (sandpaper) to produce a smooth finish.

There are several types, such as the wide belt sander, which uses an endless abrasive belt stretched over two or more drums and sands with the horizontal surface of the belt, and the drum sander, which sands with abrasive paper wrapped around the outer surface of a rotating drum.

4.4 Flooring

- End Tenoner

This machine conveys wood using a caterpillar chain, cutting both ends, shaping, and creating grooves. With blades mounted on multiple spindles, this machine can perform various operations with high precision. It is also called a tenoning machine.

A specialized tenoning machine, used to cut end joints in flooring boards and similar materials for lengthwise joining, is called an end matcher.

4.5 Wood Chips

- Chipper

These are machines that produce wood chips. Depending on the cutting method, there are types such as the disk chipper and the drum chipper.

In wood chip factories, disk chippers with chipper knives (cutting blades) mounted on a rotating disk are commonly used. In a disk chipper, the log feed opening is set at an angle to the disk, and this angle determines the cutting angle. On the machine body, a bed knife (counter knife) is fixed, and the clearance between it and the chipper knife must be adjusted. A drum chipper feeds wood against cutting knives and a counter knife mounted on a large rotating rotor, producing chips by applying impact and cutting at the same time.

In recent years, mobile chippers and truck-mounted chippers have also been introduced, and more factories are beginning to use them.

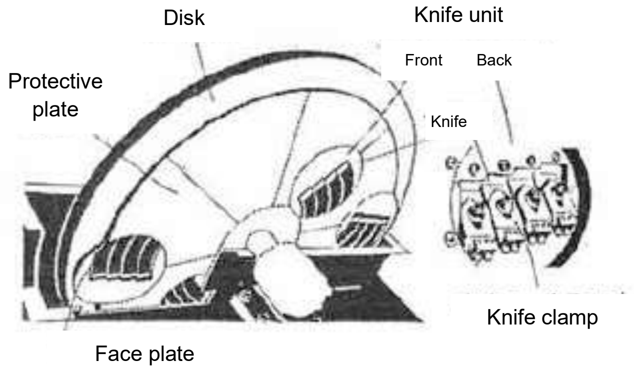


Figure 4-15: Structure of a Helical Disk Chipper
Source: "Wood Chips" by Pulpwood Communication Co., Ltd.

- Chip Screen

This is a machine that screens and sorts chips produced by a chipper into slivers (oversize chips), dust (very small chips), and product chips (chips of standard size). They are classified into rotary type, gyratory type, and vibrating type according to their operating method.

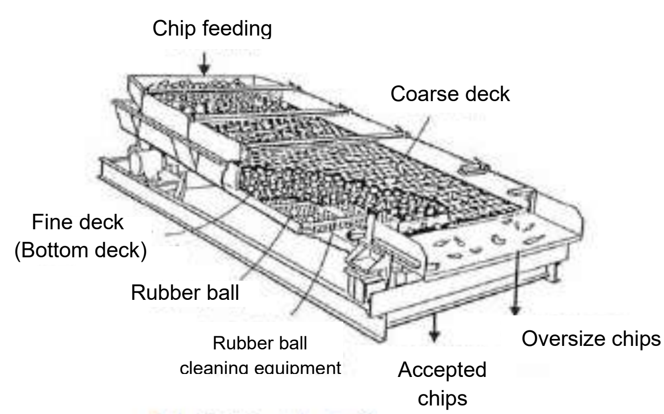


Figure 4-16: Chip Screen

Source: "Wood Chips" by Pulpwood Communication Co., Ltd.

4.6 Pre-cutting

(1) Processing Line for Beams and Columns

In the beam processing line, structural members such as sills and beams are processed, while in the column processing line, structural members such as columns and posts are processed. In many machines, as the material moves along the line, processing units are arranged so that all six surfaces (top, bottom, sides, and end faces) are machined.

At the end of each spindle, tools such as circular saws, hollow-chisel mortisers, drills, and cutters are mounted, allowing various types of joints and connections in structural members to be machined.

Figure 4-17: Beam Processing Line

(2) Processing Line for Metal Joint Construction Method

The metal joint construction method is a technique in which the joints of columns, beams, and other members in wooden frame structures are connected using special metal connectors. This has become increasingly popular because it requires minimal wood cutting and is easy to construct.

Depending on the type of metal joint used, machining such as grooves (slits) or mounting holes for hardware is required, which differs from ordinary joints and connections. In some cases, these are handled by replacing tools in the beam and column processing lines.

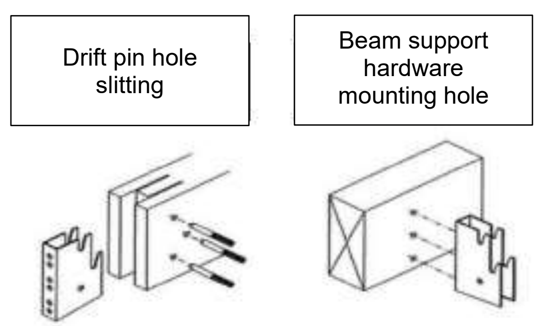


Figure 4-18: Examples of Processing Shapes in the Metal Joint Construction Method

(3) Small Structural Member Processing Machine

Small structural members refer to secondary or base members that supplement structural components, such as studs, rafters, and floor joists. Most of these members have small cross-sections, and their machining shapes are relatively simple, so many machines are designed to process large quantities of identical components.

In some machines, processing tools such as circular saws, boring bits, and diagonal-brace notch cutters are pre-set in the tool holder, allowing the machine to select the appropriate tool according to the required operation automatically.

Figure 4-19: Processing Line for Small Structural Members

(4) Plywood Processing Machines

Plywood used for roofs, floors, and walls is processed to match the required shapes. The machine is equipped with both a saw spindle and a router spindle, allowing not only cutting but also notch processing.

Figure 4-20: Plywood Processing Machines