Structure, Classification and Use of Timber

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ABSTRACT:

An overview of the structure and categorization of timber is given in this chapter. Timber, commonly referred to as wood, is a flexible and frequently used material in a variety of sectors, including building, the production of furniture, and paper. For effective exploitation and sustainable management of timber, it is essential to understand the structure and categorization of the material. The anatomical makeup of lumber is examined in this chapter, along with its growth rings, cellular structure, and physical characteristics. The categorization of lumber according to its origin, appearance, and mechanical characteristics is also covered. Professionals and researchers may choose, process, and apply wood in more effective ways by learning about its structure and categorization.

KEYWORDS:

Classification, Characteristics, Good Timber, Structure, Timber, Testing.

I. INTRODUCTION

One of the oldest and most useful materials utilized by mankind is timber, commonly known as wood. As a main construction element, fuel source, and even a means of creative expression, it has been vital to the growth of civilizations throughout history. The purpose of this article is to examine the significance of timber, as well as its qualities, uses, effects on the environment, and sustainable management techniques. Trees are a plentiful natural resource that may be found all over the world and are the source of timber [1], [2]. Due to their strength, durability, and capacity for regeneration through processes like photosynthesis, trees are the main supply of lumber. Trees must be chopped down in order to get lumber, which must then be processed for a variety of uses. The strength-to-weight ratio of wood is one of its most important characteristics. The strength, density, and durability of various tree species varies, making them appropriate for various uses. Hardwoods are well-known for their excellent strength and resilience to wear, making them perfect for furniture, flooring, and building. Examples include oak and mahogany.

Softwoods, including pine and spruce, are used often in framing, packing, and paper manufacture because they are lighter and simpler to work with. The variety of uses for timber demonstrates its adaptability. Timber is used in construction for structural elements like beams, columns, and trusses that provide structures strength and stability. Additionally, it is used to create interior finishes for things like doors, windows, floors, and cabinets, which enhances the visual appeal of rooms. Beyond building, timber is used in many consumer goods, including furniture, musical instruments, tools, sports equipment, and more. However, using wood also brings up environmental issues. Deforestation, or the destruction of forests for wood extraction and other uses, has a big impact on ecosystem services, climate change, and biodiversity. Natural ecosystems are disturbed, endangered animals are put in risk, and greenhouse gas emissions are increased. Unsustainable logging techniques can also cause water contamination, soil erosion, and the loss of cultural legacy associated with forest ecosystems.

Sustainable forest management techniques have been developed to solve these issues. With an emphasis on balancing ecological, social, and economic concerns, these methods aim to maintain the long-term health and production of forests. Planning ahead, selective harvesting, replanting initiatives, and aiding regional populations who depend on forests are all part of sustainable timber supply. Consumers may easily identify wood products that come from responsibly managed forests thanks to certification programs like those run by the Forest Stewardship Council (FSC) and the Programme for the Endorsement of Forest Certification (PEFC) [3], [4]. Additionally, engineered wood products have benefited from technological improvement. These include, among others, glued laminated timber (glulam), laminated veneer lumber (LVL), and cross-laminated timber (CLT). Engineered wood products are superior to traditional building materials like concrete and steel in terms of strength, stability, and dimensional precision.

Using lower-grade or smaller-diameter trees encourages the effective use of available wood resources. Timber is becoming more popular as a sustainable and carbon-neutral building resource in recent years. Timber structures have the capacity to absorb carbon dioxide, functioning as a carbon sink and reducing the effects of climate change. Additionally, using lumber in construction helps lessen the energy use and environmental impact of producing and delivering conventional building materials. lumber has been utilized by humans for thousands of years and is a useful and important resource. It is a priceless resource due to its special qualities, extensive use, and renewable nature. To minimize environmental effects and guarantee the long-term availability of this priceless resource, appropriate forest management and sustainable sourcing procedures are essential. We can keep using technology to profit from wood while protecting our natural ecosystems for future generations by embracing sustainable practices [5], [6].

Structure of Timber: The microscopic makeup and configuration of a piece of wood are referred to as its structure. Understanding timber's structure is crucial for understanding its characteristics, behavior, and uses. The cells, fibers, and other anatomical aspects that make up timber contribute to its strength, durability, and other qualities. Let's explore the structure of wood in further detail:

a**. Cells:** The essential components of wood are called cells, which are elongated microscopic structures that serve as the foundation for the structure of wood tissue. Parenchyma cells and fibers are the two primary kinds of cells found in wood.

b. **Parenchyma Cells:** In the tissue of wood, there exist living cells called parenchyma cells. They serve a crucial function in the storage and movement of nutrients inside the tree and have thin cell walls.

c. **Fibers:** In lumber, fibers serve as the main load-bearing component. They are stiff, elongated cells with thick walls for strength. The tree trunk's longitudinal fibers add to the overall strength of the timber by running the length of the trunk.

d. **Growth Rings:** In a cross-section of a tree trunk, you can see concentric circles that are growth rings. One year of tree development is represented by each growth ring. Due to the difference in density between the earlywood (produced during the spring's quick growth phase) and the latewood (made during the summer's slower development phase), the rings appear as alternating bands of bright and dark. The tree's growth rings may be used to estimate the tree's age and reveal important details about the tree's growing environment [7], [8].

e. **Medullary Rays:** From the core of the tree outward toward the bark are thin, radial structures known as medullary rays. They are made up of horizontal cells and aid in the radial movement of water and nutrients throughout the tree. Medullary rays in quarter-sawn wood produce a characteristic known as ray flecks, which enhance the wood's aesthetic appeal.

f. **Vessels:** Also known as pores, vessels are tubular constructions that permit the vertical movement of water and nutrients within the tree. Hardwoods tend to have more of them than softwoods. varied wood species can have vessels that have varied sizes, shapes, and arrangements, which adds to their distinctive look.

g. **Bark:** The term bark refers to the tree trunk's exterior protective coat. It is made up of multiple layers, including the phloem (which transports nutrients) and the periderm, the outermost layer that shields the tree from the elements.

Timber's physical characteristics are influenced by the cell structure, fiber density, and anatomical traits that make up the material. Strength, density, moisture content, and dimensional stability of the wood are all influenced by characteristics such as fiber spacing and orientation, the existence of growth rings, and the distribution of vessels. Engineers, architects, and artisans may choose, process, and use timber for numerous purposes, such as building, furniture manufacturing, and artistic creations, by having a thorough grasp of the structure of timber [9], [10].

II. DISCUSSION

Classification of Timber: Several characteristics of timber, such as its origin, hardness, durability, and look, can be used to categorize it. Here are some typical categories for wood:

a. **Hardwood vs. Softwood:** One of the most typical divisions of timber is between hardwoods and softwoods. Softwood is obtained from coniferous trees, whereas hardwood is obtained from broad-leaved trees deciduous trees. Hardwoods like oak, mahogany, and walnut are frequently denser, tougher, and more durable than softwoods. Softwoods like pine, spruce, and cedar are frequently utilized in construction since they are typically lighter and simpler to work with.

b. **Grade of Appearance:** Timber may be categorized according to its color, grain pattern, and inherent flaws. In order to maintain uniformity in the aesthetic attributes of the wood, appearance ratings are frequently utilized in the furniture and flooring sectors. There are several common aesthetic grades, such as clean grade free of flaws and knots, select grade, and rustic grade marked by knots and natural variances.

c. **Durability Class:** Timber may be categorized based on how resistant it is to rot and insect infestation. When choosing wood for outdoor applications or in situations with high moisture content, this categorization is crucial. Class 1 materials are highly durable, whereas Class 5 materials are very durable. Class 1 woods have a high level of decay resistance and can endure for many years without treatment, but Class 5 woods need preservative treatment when used outdoors.

d. **Strength Class:** Timber may be divided into different categories depending on its strength characteristics, which are essential for structural uses. Strength classes include details about the timber's ability to support loads. Mechanical testing establishes the strength class, which is represented by numbers or letters. For instance, in Europe, wood is divided into strength classes ranging from C14 to C50, with higher numbers signifying stronger wood.

e. **Commercial Grades:** To guarantee uniformity and quality in commercial applications, timber can be graded according to industry standards. There are several grading systems used in various nations. For instance, in North America, the Western Wood Products Association (WWPA) gives grading standards for softwoods whereas the National Hardwood Lumber Association (NHLA) offers grading guidelines for hardwoods.

f**. Sustainability Certification:** As environmental awareness grows, several categories of wood may be made depending on sustainability and ethical sourcing methods. By ensuring that wood originates from sustainably managed forests, certification programs like the Forest Stewardship Council (FSC) and the Programme for the Endorsement of Forest Certification (PEFC) support sustainable forestry techniques.

These are but a few illustrations of the numerous categories of wood. Each type serves a particular function, assisting buyers, builders, and manufacturers in selecting the best timber for their particular purposes. When choosing lumber based on its categorization, it's crucial to take into account the particular needs and qualities required for a certain project.

Characteristics of Good Timber: Good wood has a number of appealing qualities that make it excellent for a range of uses. The type of the tree, the environment it grew in, and how the timber was processed and treated all influence these qualities. Here are some essential traits of high-quality wood:

a**. Strength:** Good wood should be strong enough to handle the weights and stresses intended. It should have strong tensile, compressive, and bending characteristics to provide structural integrity in uses including building, furniture, and bridges. Different timber species have varied degrees of tensile strength, with hardwoods typically being stronger than softwoods.

b. **Durability:** The capacity of wood to withstand weathering, insect assault, and deterioration is referred to as durability. A good piece of wood should naturally resist decay and insect invasion, especially if it will be used outdoors or in areas with a lot of moisture. While softwoods like treated pine can also attain increased durability by preservative treatments, certain hardwoods like teak, cedar, and oak demonstrate great durability.

c**. Stability:** Timber should exhibit dimensional stability, which means it should be resistant to significant temperature and moisture-related warping, swelling, and distortion. The likelihood of structural problems, surface cracking, and joint failures is reduced by stable lumber. Stability is enhanced by the presence of tight, homogeneous grain patterns and growth rings.

d. **Workability:** High-quality wood should be simple to use with standard woodworking equipment. It need to have strong machining characteristics that enable operations like cutting, shaping, drilling, and joinery without causing undue tool wear or splitting. Straight-grain, uniform-texture, low-density wood is typically easier to deal with. Because they are easier to deal with, softwoods like pine and spruce are frequently used.

e. **Appearance:** The visual appeal of timber is a key quality, particularly for uses like furniture, cabinets, and interior finishings where aesthetics are crucial. A good piece of wood will have a variety of hues, grain patterns, and textures that add to its inherent beauty. The aesthetic attractiveness can be improved by the inclusion of distinctive elements like, knots, and medullary rays.

f. **Moisture Content:** A desirable timber has a moisture content that is appropriate. Taking into account elements like dimensional stability, strength, and finishing needs, it should have a moisture content that is appropriate for its intended usage. Timber that has been properly dried reduces the chance of warping, shrinking, and mold development. Different types of applications may call for different moisture content levels in the wood.

g. **Sustainability:** Good lumber should originate from sustainably managed forests and follow sustainable sourcing guidelines in the context of environmental consciousness. It is guaranteed that timber is harvested sustainably and benefits local people when it comes from certified forests, such as those recognized by the Forest Stewardship Council (FSC) or other comparable organizations.

The sum of these features determines the quality and applicability of wood for various purposes. To guarantee the best performance, lifespan, and environmental responsibility when choosing lumber, it is crucial to take these elements into account.

Seasoning of Timber: To increase timber's stability, toughness, and workability, the moisture level must be reduced through the seasoning process. Freshly cut green wood has a high moisture content that needs to be gradually decreased in order to have the best properties for different uses. The two main techniques for seasoning timber are kiln drying and air drying.

1. **Air Drying:** Exposing the wood to the natural atmospheric conditions during air drying, sometimes referred to as natural drying, enables moisture to gradually escape. Depending on the species, thickness, and environmental factors, the process might take months or even years. Timber is piled with spacers or stickers between each layer during the air drying process to encourage ventilation and stop the spread of mildew or fungus. During this phase, it's crucial to shield the wood from direct rain and very bright sunshine.

2. **Kiln Drying:** Using specially constructed kilns, kiln drying is an expedited way of seasoning lumber. Timber is placed in a controlled environment during kiln drying where temperature, humidity, and air flow may all be precisely controlled. Compared to air drying, the technique enables faster and more even moisture removal. Depending on the species and thickness of the timber, kiln drying might take a few days to a few weeks. It gives the drying process more control, which leads to more stable moisture content and better quality. Timber undergoes a number of modifications throughout the seasoning process, including:

a. **Moisture Reduction:** Seasoning's main goal is to lower the moisture content of wood. The timber eventually approaches equilibrium moisture content (EMC) with its surroundings as the moisture evaporates. Depending on the location and planned usage of the timber, the EMC varies. Increased stability, a decreased chance of warping, and better strength attributes result from lower moisture content.

b. **Dimensional Changes:** Timber shrinks in both breadth and thickness when moisture is removed. The species and grain orientation affect how much shrinking occurs. Radial shrinkage (across the growth rings) and tangential shrinkage (along the growth rings) are more important than longitudinal shrinkage (along the grain). Seasoning that is properly managed reduces dimensional changes and aids in preventing distortion or cracking.

3. **Reduction of Microorganisms:** By fostering adverse circumstances for the development of microorganisms like fungus and bacteria, seasoning suppresses their growth. A lower moisture content reduces the amount of water that is available for microbial activity, lowering the danger of rot and decay in the wood. The benefits of properly seasoned wood include increased stability, less deformation risk, increased durability, and greater workability. To maximize its performance and lifespan, lumber must be properly seasoned before being used in building, the manufacture of furniture, or other uses.

Fire Resistance of Timber: Timber's capacity to withstand the impacts of fire and retain structural integrity is referred to as its fire resistance. Even though it burns easily, wood has certain inherent fire-resistant qualities that make it ideal for a variety of purposes, including building. Considerations for determining the fire resistance of wood include ignition, flame propagation, charring, and structural performance under fire.

a. **Ignition:** The point at which wood starts to burn is referred to as the ignition. Depending on the species and moisture level, different types of wood have different ignition temperatures. Green or wet wood often burns at lower temperatures than dry wood. Timber may, however, continue to burn after being lit.

b. **Flame Spread:** The pace at which a fire spreads across a piece of wood's surface is known as flame spread. Flame propagation can be influenced by surface factors such density, moisture content, and surface coatings. Timber with low flame spread properties retards the spread of the fire and may enable fire containment.

c. **Charring:** Timber burns when it is exposed to fire, a process known as charring. The exterior layer of the timber is charred, forming a layer of char that shields and insulates the inner core. The char coating serves as a barrier, reducing the rate at which heat permeates into the wood and increasing fire resistance.

d. **Performance Structural:** Timber's fire resistance must be evaluated based on how well it performs structurally under fire circumstances. During a fire, wood keeps its ability to support weight for a while. The size, species, and conditions of the fire exposure all affect how long it will take. Fire-resistant designs, such as the use of wood pieces with larger dimensions or fire-retardant treatments, can improve performance.

In addition to timber's inherent fire resistance, there are a number of ways to enhance its fire performance.

a**. Fire Retardant Treatments:** Timber can be treated with fire retardant substances to increase its resistance to fire. These procedures entail the application of chemicals that lessen wood's combustibility, retard flame spread, and lengthen the time it takes for an ignition to occur. Timber that has been chemically treated to resist fire might contribute to your safety by postponing the start of a fire.

b. **Fire-Resistant Coatings:** To enhance the fire performance of timber surfaces, fire-resistant coatings can be used. These coatings can act as a barrier to contain the flame and slow the pace of charring. When subjected to heat, intumescent coatings, a type of fire-resistant coating, expand and provide an insulating layer.

c. **Structural Fire Design:** Designing timber structures to resist fire conditions is known as structural fire design. Taking into account things like compartmentation, fire-resistant barriers, and fire-resistant structural components are part of this. The goal of fire-resistant structural designs is to postpone the breakdown of wood components and guarantee occupant safety during a fire event.

Although lumber has naturally fire-resistant qualities and may be made more fire-resistant via different treatments, it still needs the right fire safety precautions in structures. To guarantee the secure use of timber in construction, this involves the installation of fire detection systems, fire suppression systems, and adherence to building norms and regulations.

Testing of Timber: To determine its quality, strength, durability, and appropriateness for certain purposes, timber is put through a variety of testing techniques. These tests assist establish the performance qualities of wood and guarantee adherence to industry requirements. Here are a few typical techniques for evaluating wood:

a. **Testing for moisture content:** Testing for moisture content quantifies the moisture content of wood. It is a crucial test since high moisture levels might compromise the strength, durability, and dimensional stability of wood. Moisture content can be measured non-destructively using moisture meters or in a lab setting with samples that are dried and weighed.

b. **Testing for density:** Testing for density establishes the mass per volume unit of lumber. It offers important details on the timber's mechanical, hardness, and strength characteristics. Density testing is normally done by weighing and measuring a sample of wood, then computing its density.

c. **Strength testing:** Strength testing analyzes the mechanical and load-bearing characteristics of wood. Several tests are carried out to evaluate various characteristics of strength, including:

d. **Compression Testing:** Compression tests gauge a material's resilience to compression or crushing forces. It aids in determining compressive deformation properties, elastic modulus, and compressive strength.

e. **Testing for Bending:** Bending tests measure how well wood can withstand bending or flexural forces. The modulus of rupture (MOR), modulus of elasticity (MOE), and other bending-related parameters are determined by this test.

f. **Tensile testing:** measures the tensile strength and elongation characteristics of wood. Until the samples of wood break, tension forces are applied, and the maximum load and deformation are measured.

g. **Shear Testing:** Shear tests assess the resistance of timber to pressures applied perpendicular to the grain in order to determine its shear strength. Timber samples are subjected to progressively higher shear stresses until failure in shear testing.

h. **Testing for Durability:** Testing for durability determines if wood is resistant to rot, fungus, insect infestation, and other types of degradation. These experiments replicate several environmental factors as well as contact with organisms that might hasten deterioration. They aid in determining the anticipated timber service life in particular conditions.

i. **Testing under Fire:** Testing under Fire assesses the fire resistance of wood and its behavior under Fire. Tests are conducted to measure the structural performance during fire exposure as well as the ignition qualities, flame propagation, and charring rate. The qualities of a timber product's fire safety and performance rating are determined by fire testing.

j. **Testing for Preservatives:** Testing for Preservatives measures how well wood preservatives preserve wood against deterioration, fungus, insects, and other organisms. These tests evaluate the preservatives' capacity to permeate the wood, offer lasting protection, and adhere to industry requirements.

Using standardized testing protocols developed by organizations like the American Society for Testing and Materials (ASTM), the International Organization for Standardization (ISO), and other national and international agencies, timber is frequently tested in specialist laboratories. Engineers, architects, manufacturers, and customers may all benefit from this knowledge when choosing the right wood for a variety of applications and ensuring that safety and quality criteria are being met.

III. CONCLUSION

In conclusion, wood is a necessary and renewable resource that is important to many different sectors. For best use and sustainable management techniques, it is crucial to comprehend its structure and classification. Timber's cellular structure and growth rings, which make up its anatomical makeup, have a direct impact on its physical characteristics, including strength, density, and durability. The source of the wood (hardwood or softwood), its appearance (color, grain pattern), and its mechanical characteristics (strength, stiffness) can all be used to classify timber. This categorization facilitates effective resource usage by assisting in the identification of acceptable wood species for certain purposes. Professionals may increase product quality, economic effectiveness, and environmental sustainability by taking into account the structure and categorization of timber when deciding how to handle, preserve, and use it. Future wood resource exploitation and protection will benefit from ongoing study and information exchange in this area.

REFERENCES

[1] J. Hallik and T. Kalamees, Development of Airtightness of Estonian Wooden Buildings, J. Sustain. Archit. Civ. Eng., 2019, doi: 10.5755/j01.sace.24.1.23231.

[2] C. P. Celani, C. A. Lancaster, J. A. Jordan, E. O. Espinoza, and K. S. Booksh, Assessing utility of handheld laser induced breakdown spectroscopy as a means of: Dalbergia speciation, Analyst, 2019, doi: 10.1039/c9an00984a.

[3] J. Hallik and T. Kalamees, Development of airtightness of estonian wooden buildings, J. Sustain. Archit. Civ. Eng., 2019, doi: 10.5755/j01.sace.24.1.22167.

[4] M. C. de J. A. Nogueira et al., Physical and mechanical properties of Eucalyptus saligna wood for timber structures, Ambient. Construído, 2019, doi: 10.1590/s1678-86212019000200319.

[5] A. Fauzy, Metode Sampling. 2019.

[6] Nadia and Dkk, Departemen Ilmu Kesehatan Mata Fakultas Kedokteran Universitas Padjadjaran Pusat Mata Nasional Rumah Sakit Mata Cicendo Bandung, J. Wind Eng. Ind. Aerodyn., 2019.

[7] J. A. J. Huber, M. Ekevad, U. A. Girhammar, and S. Berg, Structural robustness and timber buildings–a review, Wood Material Science and Engineering. 2019. doi: 10.1080/17480272.2018.1446052.

[8] F. Wiesner et al., Structural capacity in fire of laminated timber elements in compartments with exposed timber surfaces, Eng. Struct., 2019, doi: 10.1016/j.engstruct.2018.10.084.

[9] J. Stenson et al., Monitored indoor environmental quality of a mass timber office building: A case study, Buildings, 2019, doi: 10.3390/BUILDINGS9060142.

[10] C. Piponiot et al., Can timber provision from Amazonian production forests be sustainable?, Environ. Res. Lett., 2019, doi: 10.1088/1748-9326/ab195e.