

Classification of Woods: Types and Applications

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ABSTRACT:

Based on their physical and chemical characteristics, woods are categorized in this chapter. In many different sectors, including building, furniture production, and handicraft, wood is a flexible and commonly utilized material. When choosing the right wood species for a certain application, it is crucial to comprehend the many types of wood and their properties. This categorization divides woods into groups according to their density, hardness, grain patterns, and other essential characteristics. For experts and hobbyists working with wood, this knowledge is an invaluable resource.

KEYWORDS:

Chemical Properties, Construction, Mechanical Properties, Significance, Wood.

I. INTRODUCTION

A unique substance, wood has been instrumental in the growth of human civilization. Wood has played a significant role in human lives for thousands of years, from supplying warmth and shelter to sustaining businesses and serving as an inspiration for artistic works. We will examine the numerous facets of wood, its qualities, applications, and relevance in our world. Trees are woody plants with a trunk, branches, and leaves that provide wood as a natural resource [1], [2]. Through the process of photosynthesis, which involves the absorption of carbon dioxide and the release of oxygen, trees are essential to preserving the ecological balance. They also contribute to the general health of our planet by serving as habitat for innumerable species. Wood is a great material because of its adaptability. It is a resource that may be gathered and used in a variety of ways since it is sustainable and renewable. Different varieties of wood have unique physical and chemical characteristics that make them suited for particular uses. For instance, hardwoods like oak and mahogany are renowned for their strength and durability, making them perfect for building and furniture [3], [4].

On the other hand, softwoods like pine and cedar are lighter and easier to work with, making them popular options for carpentry and woodworking tasks. For millennia, wood has been utilized in building. It is a fantastic material choice for constructing buildings because of its distinctive blend of toughness, longevity, and beauty. Wood has been a dependable and attractive building material for centuries, used by ancient civilizations to build log huts and modern builders to create timber-framed buildings. It has great insulating qualities that aid with temperature control and lower energy use. Furthermore, it is challenging to duplicate the warm and welcoming atmosphere of wooden constructions with other materials. Wood is used in furniture production in addition to building. Wood is a favorite material for creating stylish and useful furniture because of its warmth and natural beauty. Expert craftspeople may combine practicality with aesthetic ideas to create stunning chairs, tables, cabinets, and beds out of raw timber.

The abundance of wood species accessible gives furniture producers' limitless options for colors, textures, and finishes, enabling them to produce one-of-a-kind items. Wood is important in the fields of art and handicraft as well. Intricate motifs and patterns are carved into blocks of wood as part of the ancient art of wood carving. Sculptors may give their ideas life by producing gorgeous sculptures, figurines, and home accents. Another old-fashioned art is turning wood into bowls, vases, and other cylindrical things with a lathe. Wood has a huge aesthetic potential and continues to be a source of inspiration for designers and makers around. In addition to being beautiful and creative, wood is a source of energy. Since the beginning of time, people have heated and cooked their homes using firewood. In many regions of the world today, wood is still a crucial source of fuel. Wood is a carbon-neutral fuel source because trees absorb an equivalent amount of carbon dioxide during growth, despite the fact that burning it releases carbon dioxide. Additionally, wood has significantly impacted a number of sectors.

Wood is a major raw material used by the pulp and paper industry to make paper, cardboard, and other items made of paper. Wood fibers must be broken down and reshaped into the proper shapes as part of the process.

Additionally, wood is utilized in the manufacturing of a variety of wood-based panels, including plywood and particleboard, which have many uses in building and furniture manufacture. Despite the fact that wood is a valuable resource, its exploitation and use must be managed responsibly. The ecosystem might be negatively impacted by deforestation, illicit logging, and other unsustainable practices. To guarantee the long-term supply of wood supplies, it is essential to encourage appropriate forestry methods, such as replanting and selective logging.

Importance of Wood in Construction: Construction relies heavily on wood and wood products, which have been utilized in various ways for ages. Because of its special qualities and benefits, wood is essential in building. Let's look at some of the main factors that make wood important in the building sector.

a. **Strength and Durability:** Wood is a sturdy and long-lasting material, particularly when it is used to make engineered wood goods like cross-laminated timber (CLT) or hardwoods like oak. It can endure high weights and pressures and has good load-bearing characteristics. Wooden constructions with proper design and upkeep may persist for many generations.

b. **Flexibility and Versatility:** Wood is versatile and flexible when it comes to design and construction. It is simple to shape, cut, and put together to make intricate architectural creations. Wood is used for many different things, including wall and door construction, roofing, flooring, and window and door frames. Its adaptability enables architects and builders to realize cutting-edge and distinctive designs [5], [6].

c. **Thermal Insulation:** Wood naturally has the ability to act as a thermal insulator. As opposed to substances like metal or concrete, it has low thermal conductivity, making it a poor heat conductor. By decreasing the need for a lot of heating or cooling and maintaining a pleasant interior temperature, this characteristic helps conserve energy.

d. **Sustainability and Environmental Benefits:** Wood is a resource that may be exploited sustainably. A steady supply of wood is guaranteed by well managed forests since removed trees are replaced by new ones that are planted. Additionally, as wood ages, it absorbs carbon, lowering the atmospheric concentration of carbon dioxide. By storing carbon, using wood in building helps to combat climate change [7], [8].

e. **Warmth and Beauty:** Wood brings a touch of warmth and natural beauty to architectural settings. Wood grain patterns, textures, and colors combine to provide an attractive setting. An environment made cozier and more welcoming by the presence of wood can improve a building's overall comfort and visual appeal [9], [10].

f. **Lighter Weight:** Wood is quite lightweight when compared to many other building materials, such as concrete or steel. This quality facilitates handling and transportation during construction. Additionally, it lessens the strain on the building's base and structural components, which might result in cost savings during building design and construction.

g. **Construction Efficiency and Speed:** Using wood construction methods like prefabrication or timber framing helps speed up construction. Wood components may be precisely manufactured and assembled more quickly on-site thanks to off-site fabrication, which also speeds up construction and lowers costs.

h. **Acoustic Performance:** Wood has great sound-insulating qualities that lessen sound transmission from outside sources or between rooms. It is especially appropriate for situations where noise reduction is vital, including theaters, music halls, or residential buildings since it helps create a calmer and more serene interior atmosphere.

i. **Earthquake Resistance:** Due to its natural flexibility, wood can absorb and disperse energy during earthquake occurrences. Because wood is more resistant to ground disturbances than more rigid materials, it can provide a higher level of safety in earthquake-prone locations.

j. **Recyclability and Waste Reduction:** At the end of its life cycle, wood may be recycled and used to make new items. Additionally, wood waste produced during building or demolition may be turned into composite panels or wood pellets, which are both useful commodities.

there is no denying the value of wood and wood products in building. Wood is still a favorite material for architects, builders, and homeowners alike because of its strength, adaptability, sustainability, aesthetic appeal, and many other benefits. Its usage in building encourages environmentally friendly methods, energy-saving techniques, and the design of stunning and useful structures.

II. DISCUSSION

Significance of Wood: Beyond its usefulness, wood has enormous symbolic value. Its significant impact on culture, history, and the environment has influenced human civilization for many years. Let's examine the significance of wood in its many aspects.

a. **Cultural and Historical Importance:** Wood has been essential to the historical and cultural growth of cultures all throughout the world. It has been incorporated into conventional arts, crafts, and architecture, expressing the distinctive identities and histories of many civilizations. Wood has had a lasting impression on human history and creative expression, from finely carved wooden sculptures to age-old wooden temples and castles.

b. **Relationship with Nature:** Wood provides a physical link to the natural world. Wood, a byproduct of trees, serves as a constant reminder of how important forests are to maintaining life as we know it. It encourages an awareness and respect for the environment and serves as a reminder of the importance of sustainable behaviors in order to preserve and maintain our woods.

c. **Sustainability and Environmental Importance:** When used properly, wood is a renewable resource. Replanting trees is a key component of sustainable forestry methods to guarantee the long-term supply of wood supplies. In addition to providing wood, forests are important for carbon sequestration, biodiversity preservation, and ecosystem health. By storing carbon and replacing more energy-intensive materials like concrete or steel with wood, wood is used in construction and other uses to help decrease carbon emissions.

d. **Biophilic Design and Well-Being:** To improve human well-being and connection to nature, biophilic design strives to incorporate natural components, especially wood, into the built environment. People are calmed and soothed by the natural textures, hues, and patterns of wood, which helps to relieve stress and promote mental health. Exposure to wood in enclosed environments has been demonstrated to increase pleasure, productivity, and creativity.

e. **Economic Significance:** The wood business has a considerable impact on both national and international economies. From logging and forestry through manufacturing, building, and wood processing, it offers job prospects. Global commerce in wood products helps many areas' lives and economic growth.

f. **Spiritual and Symbolic Significance:** Wood has carried spiritual and symbolic importance throughout history in a number of different civilizations and faiths. Wood has always been connected to spiritual activities and beliefs, from the holy groves of ancient civilizations to the usage of wooden artifacts in religious rites and celebrations. Its connection to the Earth and natural beginnings have made it a symbol of resiliency, growth, and life.

g. **Sustainable Energy Source:** Wood is a renewable energy source that is also a sustainable energy source. It may be used as fuel or processed into wood chips or pellets to provide biomass energy. Wood-based biomass energy can help promote a more sustainable energy mix by lowering reliance on fossil fuels.

h. **Warmth and Comfort:** Wood has a special potential to provide indoor environments a feeling of coziness, warmth, and comfort. Wood is a desirable material in residential and hospitality settings because of the natural colours, textures, and fragrances that it elicits.

i. **Value in terms of Education and Recreation:** Wood provides opportunity for both. Environmental awareness and a respect for the variety of trees and forests are encouraged by learning about various wood species, their traits, and functions. Woodworking and carpentry are hobbies that allow people to interact with the material and produce useful or beautiful objects. They also give avenues for creativity and skill development.

wood has value that goes beyond its usefulness. It includes aspects related to culture, history, the environment, and even religion. Humans have a strong emotional connection to wood because of its sustainability, capacity to build visually beautiful settings, and connection to nature. Wood will continue to be a priceless and beloved resource in our lives as we continue to understand the significance of sustainability and the advantages of biophilic architecture.

Factors Considered in Wood Classification: distinct varieties of wood are categorized based on a number of distinct criteria. Understanding a wood's characteristics, prospective applications, and general appropriateness for a given task depends on how it is classified. When classifying wood, a number of criteria are taken into account, including:

a. **Hardwood vs. softwood:** One of the main divisions of wood is determined by the botanical origin of the material. Softwood originates from coniferous trees like pine, cedar, and fir, whereas hardwood comes from deciduous trees like oak, maple, and mahogany. Although there are few exceptions, hardwood is typically denser and tougher than softwood. Understanding how different types of wood behave and their overall qualities is made easier by this classification.

b. **Density:** The mass of wood per unit volume is referred to as wood density. It is frequently quantified using specific gravity. Ebony and lignum vitae are examples of high-density timbers that are heavier and more compact, whereas cork and balsa are examples of low-density woods that are lighter and less dense. Wood's density has an impact on its strength, use, and workability, making it a crucial categorization criterion.

c. **Grain Structure:** The arrangement of wood fibers within a tree's growth rings is referred to as the grain structure. Among other things, it can be categorized as straight, interlaced, or spiral. Ash and birch have straight-grained wood, which is easier to work with since the fibers run parallel to the trunk. The twisting or crossing of the fibers of interlocked or spiral-grained wood, such as mahogany or teak, can alter the strength and workability of the wood.

d. **Color and Appearance:** Wood comes in a broad variety of hues, from pale blondes to deep browns or reds. Factors including tree type, age, growth circumstances, and treatment affect the color. The look consists of features such as a tiger stripe or a bird's eye, texture, and gloss. Furniture, flooring, and ornamental uses all take color and look into account.

e. **Moisture Content:** Wood has moisture, and the quantity of water it contains influences its stability, tensile strength, and workability. The proportion of the weight of water in relation to the weight of the dry wood is used to represent the moisture content. In terms of moisture content, wood can be categorized as green freshly cut with a high moisture content, air-dried, or kiln-dried. In order to avoid warping, splitting, or deterioration, it is essential to maintain moisture content properly.

f. **Durability and Decay Resistance:** The inherent durability and resistance to decay, insects, and fungus of various wood species varies. Redwood, teak, and cedar are examples of woods that are appropriate for outdoor use since they naturally resist degradation. The durability categorization of wood makes it easier to choose the best wood for particular applications and environmental circumstances.

g. **Workability:** The ability of wood to be machined, shaped, joined, and finished is referred to as workability. It takes into account elements like toughness, rigidity, straightness, and ease of sawing, planing, carving, and sanding. In carpentry and woodworking, workable woods like maple or beech are recommended; woods with high density or interlocking grain may be more difficult to work with.

h. **Chemical Properties:** Some types of wood have distinct chemical characteristics that make them appropriate for various applications. For instance, cedar and cypress woods have natural oils or resins that protect them against decay and insects. The reactivity of the wood to adhesives, coatings, or treatments might also depend on its chemical characteristics.

The properties and usefulness of various types of wood for different uses are determined through the complicated process of wood categorization, which takes these and other aspects into account. Understanding these categories makes it easier to choose the ideal wood for certain projects, providing top performance and durability.

Mechanical Properties of Wood: Wood is excellent for a variety of applications due to its distinct mechanical characteristics. Numerous elements, including as species, density, moisture content, and grain orientation, have an impact on the mechanical characteristics of wood. Some of the main mechanical characteristics of wood include:

a. **Strength:** Wood has tensile strength, which is the ability to resist stretching or pulling pressures, as well as compressive strength, which is the ability to resist crushing or pushing forces. The species and density of wood affect its strength in different ways. In general, hard woods are stronger than soft woods. The strength qualities are also influenced by the direction of the applied force in relation to the grain orientation.

b. **Stiffness:** The resistance of the wood to deformation under an applied stress is referred to as stiffness, also known as modulus of elasticity. It calculates how much the wood will flex or bend in response to a force. Factors including species, density, and grain orientation affect stiffness. Greater stiffness may be seen in woods with a straight grain and a high density.

c. **Hardness:** The resistance of the wood to dents or scratches is referred to as hardness. It is a gauge of the wood's resistance to certain forces. The hardness of various wood species varies, with certain hardwoods, such as hickory or maple, being noticeably harder than softwoods, such as pine or cedar. The usefulness of the wood for uses where resistance to wear or impact is vital might depend on its hardness.

d. **Toughness:** The capacity of a substance to absorb energy without breaking is known as its toughness. It combines ductility and strength. Wood has some degree of toughness, even if it is not as tough as some metals or manufactured materials. This is especially true when compared to brittle materials. Indicators of toughness include species, grain orientation, and moisture content.

e. **Elasticity:** Wood may distort when subjected to load, but if the stress is removed, it will resume its former shape. Wood is able to sustain numerous stress cycles thanks to its characteristic without suffering considerable long-term deformation. The modulus of elasticity of wood, which is related to its stiffness, determines the material's elasticity.

f. **Anisotropy:** The mechanical characteristics of wood are orientation dependent. Wood is anisotropic because the varying grain orientations greatly alter its mechanical characteristics. Wood is strongest and stiffest longitudinally (along the grain) and least so radially and tangentially (across the grain). When choosing wood for certain uses or creating buildings, anisotropy should be taken into account.

g. **Effects of Moisture:** Variations in moisture content have a substantial impact on wood's mechanical characteristics. Wood expands or contracts when it gains or loses moisture, which can result in dimensional changes as well as changes to strength and stiffness. For optimal design and application, it is crucial to comprehend the moisture-related behavior of wood. It's crucial to remember that wood's mechanical qualities can fluctuate greatly between species, even within the same species, and depend on things like growing circumstances and treatment. Due to the inherent heterogeneity of wood as a natural material, individual wood samples or species must be tested and evaluated in order to acquire exact mechanical property data for engineering applications.

Chemical Properties of Wood: Numerous chemical characteristics of wood influence its composition, behavior, and appropriateness for different uses. These characteristics are built into the structure of wood and may be affected by things like species, growing circumstances, and treatment. Some essential chemical characteristics of wood include:

a. **Cellulose:** Cellulose, which accounts for between 40 and 50 percent of the chemical makeup of wood, is the main component. It is a type of complex carbohydrate made up of extended glucose molecule chains. Cellulose gives wood fibers structural strength and helps to make them rigid and durable.

b. **Lignin:** Lignin, which makes up 20–30% of a wood's makeup, is another important component. The natural glue that holds the cellulose fibers together is an amorphous polymer. Lignin significantly influences the mechanical characteristics of wood and adds to its stiffness and density.

c. **Hemicellulose:** Hemicellulose, which accounts for 20–30% of the composition of wood, is a collection of complex polysaccharides. It gives the wood structure some flexibility and serves as a binding agent for the cellulose fibers. The difference in water solubility between cellulose and hemicellulose has an impact on the hygroscopic properties of wood.

d. **Extractives:** Extractives are organic chemical substances that are naturally found in wood but are not structurally necessary. They consist of oils, tannins, pigments, resins, and other organic compounds. Wood's color, fragrance, and ability to fend off insects and rot are all influenced by extractives. They may also impact how easily the wood can be finished and worked.

e. **Moisture Content:** Depending on the climate, wood has the capacity to absorb and release moisture. Water in wood alters its mechanical and physical characteristics. The strength, stiffness, and stability of wood may all be impacted by variations in moisture content, which can also lead to dimensional changes like swelling or shrinking.

f. **pH and Acidity:** The pH range of wood is normally between 4 and 6.5, making it mildly acidic in nature. The interaction of wood with other substances, such as metals or adhesives, can be impacted by its acidity. When choosing the right treatments, finishes, or adhesives, it's crucial to take the pH of the wood into account to ensure compatibility.

g. Decay Resistance: Some wood species are inherently resistant to fungus and insects, two types of creatures that cause decay. The extractives found in the wood, including resins or oils, are principally responsible for these inherent decay-resistant qualities. Wood's ability to resist decay varies depending on the species, and it may be improved with the right treatment.

h. Fire Resistance: Wood is flammable and can catch fire when exposed to flames. However, its chemical composition may have an impact on how it burns. Some wood species have higher levels of chemicals that resist fire, such as lignin, which can result in slower burning rates or the development of a protective char coating.

i. Chemical Reactivity: Wood can react chemically to specific substances or environmental factors. For instance, exposure to acids, alkalis, or potent oxidizing agents can have an impact on wood. Color changes, deterioration, or modifications to the qualities of the wood might result from chemical interactions.

For a variety of uses, including wood preservation, treatment, and compatibility with coatings or adhesives, it is crucial to understand the chemical characteristics of wood. These characteristics affect how wood behaves in various contexts and can direct how to handle, treat, and use this adaptable natural material.

III. CONCLUSION

In conclusion, a systematic framework for comprehending and classifying various types of wood is provided by the categorization of woods based on their physical and chemical qualities. Professionals and amateurs may choose the best wood species for their unique needs by carefully considering characteristics like density, hardness, and grain patterns. This categorization system, which takes into consideration elements like durability, workability, and beauty, helps ensuring that the selected wood is appropriate for a certain purpose. It also makes it easier for those who deal with wood to communicate and share expertise, enabling the efficient and effective use of this priceless natural resource.

REFERENCES

- [1] H. Kim et al., Visual classification of wood knots using k-nearest neighbor and convolutional neural network, *J. Korean Wood Sci. Technol.*, 2019, doi: 10.5658/WOOD.2019.47.2.229.
- [2] V. Nasir, S. Nourian, S. Avramidis, and J. Cool, Classification of thermally treated wood using machine learning techniques, *Wood Sci. Technol.*, 2019, doi: 10.1007/s00226-018-1073-3.
- [3] S. Santosa, R. A. Pramunendar, D. P. Prabowo, and Y. P. Santosa, Wood types classification using back-propagation neural network based on genetic algorithm with gray level co-occurrence matrix for features extraction, *IAENG Int. J. Comput. Sci.*, 2019.
- [4] M. B. Vicari, M. Disney, P. Wilkes, A. Burt, K. Calders, and W. Woodgate, Leaf and wood classification framework for terrestrial LiDAR point clouds, *Methods Ecol. Evol.*, 2019, doi: 10.1111/2041-210X.13144.
- [5] X. Cui, Q. Wang, Y. Zhao, X. Qiao, and G. Teng, Laser-induced breakdown spectroscopy (LIBS) for classification of wood species integrated with artificial neural network (ANN), *Appl. Phys. B Lasers Opt.*, 2019, doi: 10.1007/s00340-019-7166-3.
- [6] J. Yang, P. Huang, F. Dai, Y. Sun, L. Wang, and H. Bi, Application of Deep Learning in Wood Classification, in *2019 IEEE International Conference on Computer Science and Educational Informatization, CSEI 2019*, 2019. doi: 10.1109/CSEI47661.2019.8938960.
- [7] Z. Nurthohari, M. A. Murti, and C. Setianingsih, Wood quality classification based on texture and fiber pattern recognition using HOG feature and SVM classifier, in *Proceedings - 2019 IEEE International Conference on Internet of Things and Intelligence System, IoTaIS 2019*, 2019. doi: 10.1109/IoTaIS47347.2019.8980414.
- [8] E. V. M. Carrasco, L. B. Passos, S. T. A. Amorim, F. M. G. Ramos, F. C. Rodrigues, and J. N. R. Mantilla, Glulam wood sleepers manufacturing from recycling discharge sleepers: An engineering recycling project, *BioResources*, 2019, doi: 10.15376/biores.14.3.5059-5070.
- [9] S. Li, D. Li, and W. Yuan, Wood Defect Classification Based on Two-Dimensional Histogram Constituted by LBP and Local Binary Differential Excitation Pattern, *IEEE Access*, 2019, doi: 10.1109/ACCESS.2019.2945355.
- [10] Y. Susanti et al., Classification of teak wood production in Central Java using the C5.0 algorithm, in *AIP Conference Proceedings*, 2019. doi: 10.1063/1.5141707.