Chapter 30: Wood and Wood Products – Timber: Classification, Structure, Properties

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Introduction

Timber, a principal building material since ancient times, continues to play a crucial role in civil engineering due to its availability, workability, strength-to-weight ratio, and aesthetic appeal. The study of wood and wood products is essential for understanding the performance of wooden structures, design practices, and durability under various conditions. Timber, obtained from trees, varies significantly in its characteristics based on species, growth environment, and age. This chapter deals with the classification, structure, and properties of timber, equipping students with the knowledge to evaluate its suitability in different civil engineering applications.

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1. Classification of Timber

Timber can be classified in several ways, based on **origin**, **mode of growth**, **durability**, and **structure**. The major classifications are discussed below:

1.1 Based on Botanical Origin

- **Hardwood**:
  - Derived from **angiosperms (broad-leaved trees)**.
  - Examples: Teak, Sal, Oak, Mahogany.
  - Characteristics: Dense, strong, usually dark in color, slower growth.
  - Applications: Furniture, flooring, doors, high-end construction.
- **Softwood**:
  - Derived from **gymnosperms (coniferous trees)**.
  - Examples: Pine, Fir, Cedar, Spruce.
  - Characteristics: Lightweight, less dense, usually light in color.
  - Applications: General construction, scaffolding, temporary structures.

1.2 Based on Mode of Growth

- **Exogenous Trees**:
  - Grow outward by forming **annual rings**.
  - Example: Teak, Sal, Deodar.
  - **Preferred in construction** due to greater strength and clear grain patterns.

- **Endogenous Trees**:
  - Grow inward with fibrous structures; lack distinct rings.
  - Example: Bamboo, Palm.
  - **Not suitable for structural use** due to irregular structure.

1.3 Based on Durability

- **High Durability**:
  - Naturally resistant to pests, decay, and moisture.
  - Example: Teak, Sal.
- **Moderately Durable**:
  - Require seasoning and chemical treatment.
  - Example: Deodar, Mango.
- **Non-Durable**:
  - Prone to attack and decay; suitable only after treatment.
  - Example: Kail, Fir.

1.4 Based on Use

- **Structural Timber**: Used for load-bearing components (e.g., beams, posts).
- **Carpentry Timber**: Used for joinery, paneling, furniture.
- **Industrial Timber**: Processed for boards, veneers, plywood, etc.

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2. Structure of Timber

Understanding the internal structure of timber is key to evaluating its mechanical properties and behavior under stress.

2.1 Macroscopic Structure

a) Bark:

- Protective outer layer.
- Not used in construction.

b) Cambium Layer:

- Thin layer between bark and wood.
- Responsible for growth in thickness.

c) Sapwood:

- Outer portion of the wood.
- Lighter in color; stores and conducts sap.
- Less durable and more prone to decay.

d) Heartwood:

- Inner, darker part of wood.
- Older, harder, and more durable.
- Used in construction due to strength.

e) Annual Rings:

- Represent yearly growth; count indicates tree age.
- Each ring includes earlywood (springwood – lighter, porous) and latewood (summerwood – darker, denser).

f) Medullary Rays:

- Radial bands from center to bark.
- Help in radial conduction of nutrients.

g) Pith:

- Central core; weak and soft.
- Generally avoided in structural timber.

2.2 Microscopic Structure

- Timber is made of **tracheids, vessels, fibers, and parenchyma**.
- **Hardwoods**: Contain vessels (pores) – visible as grain.
- **Softwoods**: Primarily tracheids – fewer pores.
- Cell orientation and density influence mechanical properties.

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3. Properties of Timber

Timber's properties influence its selection for various civil engineering purposes. These properties are divided into:

3.1 Physical Properties

a) Appearance:

- Color, grain, and texture vary by species.
- Determines aesthetic value.

b) Weight:

- Depends on moisture content and density.
- Generally ranges from 400–1000 kg/m³ for seasoned timber.

c) Moisture Content:

- Freshly cut timber may contain up to 100% moisture.
- Seasoned timber has ~10–20% moisture content.

d) Shrinkage and Swelling:

- Due to change in moisture content.
- Greatest in tangential direction, least in longitudinal.

e) Odor and Taste:

- Some woods have distinctive smells (e.g., cedar).
- Useful for identification, though not a structural criterion.

3.2 Mechanical Properties

a) Strength:

- Varies with species, grain orientation, and defects.
- Types:
  - **Compressive Strength**: High along the grain (parallel).
  - **Tensile Strength**: Also higher along the grain.
  - **Shear Strength**: Usually low in cross grain.

b) Elasticity:

- Exhibits viscoelastic behavior.
- Timber behaves elastically under normal loads.

c) Toughness:

- Resistance to sudden shocks or loads.
- Important in dynamic or impact-prone structures.

d) Hardness:

- Resistance to indentation and abrasion.
- Relevant for flooring and wear surfaces.

3.3 Thermal and Acoustic Properties

- **Low thermal conductivity** – makes timber a good insulator.
- **Good sound absorption** – used in auditoriums and soundproofing.

3.4 Durability and Decay Resistance

- Varies with species and presence of natural oils/resins.
- Susceptible to fungal decay, termites, and insects.
- Can be improved by **seasoning** and **chemical treatment**.

3.5 Fire Resistance

- Timber is combustible but chars on the outside, which insulates the inner core.
- Large sections have better fire resistance than expected due to charring.

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4. Defects in Timber (Brief Overview)

Timber may be affected by natural or seasoning-induced defects:

- **Knots**: Portions of branches within wood.
- **Shakes**: Cracks along growth rings (e.g., star shake, heart shake).
- **Warping**: Twisting or bending during drying.
- **Cupping, Bowing, Twisting**: Deformation due to uneven shrinkage.

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5. Seasoning of Timber (Introduction)

Seasoning is the process of reducing moisture content to improve strength, durability, and dimensional stability. Methods include:

- **Natural Seasoning (Air drying)**
- **Artificial Seasoning (Kiln drying, boiling, chemical)**

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6. Industrial Wood Products (Preview)

Engineered wood products are manufactured for uniformity and improved strength:

- **Plywood**
- **MDF (Medium Density Fiberboard)**
- **Particle Board**
- **Laminated Veneer Lumber (LVL)**
- **Glue-laminated timber (Glulam)**

These are used in situations requiring dimensional stability, light weight, and cost-effectiveness.

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7. Seasoning of Timber (Detailed)

Seasoning is essential before using timber in construction. Improperly seasoned timber may shrink, warp, decay, or lose strength. The purpose is to reduce **moisture content** to a level appropriate for the timber's intended use.

7.1 Objectives of Seasoning

- To reduce weight and increase strength
- To increase resistance to decay and insects
- To improve insulation properties
- To enhance paint and preservative penetration
- To prevent excessive shrinkage and warping

7.2 Types of Seasoning

A. Natural Seasoning (Air Seasoning)

- Timber is stacked in well-ventilated, shaded areas with adequate spacing.
- End coatings (tar/paint) may be applied to prevent end cracking.
- Duration: **6–12 months or more** depending on species and size.
- **Advantages**:
  - Economical
  - Environment-friendly
- **Disadvantages**:
  - Slow
  - Weather dependent
  - Susceptible to insect/fungal attacks during process

B. Artificial Seasoning Accelerated drying using controlled heat, humidity, and air flow.

1. **Kiln Seasoning**:
   - Timber is placed in a kiln with regulated temperature/humidity.
   - Most effective and controlled method.
   - Types: **Compartmental kiln**, **Progressive kiln**
   - **Advantages**:

  - Quick and uniform
  - Can treat large quantities
  - Reduces defects like cracking
- **Disadvantages**:
  - Expensive
  - Requires skilled supervision

2. **Boiling**:
   - Timber is boiled in water or steam-chambered for hours.
   - Opens up wood cells and allows rapid moisture loss.
   - Effective but may degrade strength slightly.
3. **Chemical Seasoning**:
   - Uses salt solution or urea compounds to draw moisture.
   - Good for dense woods.
4. **Electrical Seasoning**:
   - High-frequency electric currents evaporate water inside the timber.
   - Fast but suitable only for small sections.

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8. Preservation of Timber

Even well-seasoned timber is vulnerable to biological agents like fungi, termites, beetles, and marine borers. **Preservatives** protect timber and extend its life.

8.1 Objectives of Preservation

- To increase timber life
- To improve resistance against insects and fungi
- To prevent rot and degradation in humid environments

8.2 Types of Preservatives

1. **Oil-based Preservatives**:
   - *Example*: Creosote oil, Coal tar
   - Applied via brushing, spraying, or dipping
   - Excellent resistance to water and insects
   - Commonly used for railway sleepers, poles
2. **Water-soluble Preservatives**:
   - *Examples*: Copper sulphate, Zinc chloride
   - Applied by dipping or pressure treatment
   - Less effective in wet areas unless fixed with additives

3. **Chemical Salts and Organophosphates**:
    - Used in advanced preservation for marine and tropical use

8.3 Methods of Preservation

1. **Brushing and Spraying**:
    - Quick, cheap
    - Limited penetration
2. **Soaking and Dipping**:
    - Timber is soaked in preservatives for hours/days
    - Suitable for small sections
3. **Hot and Cold Treatment**:
    - Timber is alternately heated and cooled in preservative solutions
    - Causes deep penetration
4. **Pressure Treatment (Full-cell or Empty-cell)**:
    - Performed in pressure cylinders
    - Most durable and deep-penetrating method
    - Used in commercial and marine-grade timbers

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9. Industrial/Engineered Wood Products

Industrial wood products are **reconstituted or engineered** to address limitations of natural timber such as dimensional instability, knots, and variability.

9.1 Plywood

- Made by gluing together thin layers (**veneers**) of wood with grains at right angles.
- Types:
    - **Commercial plywood**
    - **Marine plywood** (waterproof)
    - **Shuttering plywood** (concrete formwork)
- **Advantages**:
    - High strength-to-weight ratio
    - Good dimensional stability
    - Reduced splitting

9.2 Blockboard and Laminboard

- **Blockboard**: Core of softwood strips sandwiched between veneers.
- **Laminboard**: Similar but core is made of thin wooden slats.

9.3 Particle Board

- Made by compressing wood particles with resin under heat.
- Economical but lower strength.
- Used for furniture, partition panels, ceiling tiles.

9.4 Medium Density Fibreboard (MDF)

- Made from wood fibers and resin.
- Smooth surface; easy to shape, machine, and paint.
- Used in furniture, interior applications.

9.5 Oriented Strand Board (OSB)

- Made by compressing wood flakes in specific orientations.
- Used as structural panels, floor and roof sheathing.

9.6 Laminated Veneer Lumber (LVL)

- Multiple veneers are bonded in parallel grain orientation.
- Strong and suitable for heavy structural members (like beams).

9.7 Glued Laminated Timber (Glulam)

- Made by bonding layers of timber with adhesive.
- High strength, used in long-span arches, bridges, industrial sheds.

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10. Environmental Considerations in Timber Use

- **Sustainability**: Timber is renewable if sourced from certified forests.
- **Carbon Sequestration**: Stores carbon during growth.
- **Eco-Friendly Alternatives**: Engineered wood reduces logging pressure on forests.
- **Waste Utilization**: By-products like sawdust and chips used in boards.
