Chapter 32: Wood and Wood Products – Testing and Preservation of Timber

Introduction

Timber has been one of the oldest and most versatile construction materials used in civil engineering. Its ease of workability, aesthetic appeal, and sustainability make it valuable for structural and non-structural applications. However, as a natural material, timber is subject to variability in properties and vulnerability to degradation over time due to environmental factors, biological agents, and mechanical stresses. To ensure safety, performance, and longevity, rigorous testing and appropriate preservation methods are crucial.

This chapter discusses the various tests conducted to assess the quality of timber, standards applicable, and preservation techniques used to enhance its durability.

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1. Testing of Timber

The testing of timber is carried out to evaluate its **mechanical**, **physical**, and **biological** properties. Standard testing ensures that timber meets the design specifications and performs reliably under expected service conditions.

1.1 Visual Inspection

- **Purpose**: To detect defects such as knots, checks, shakes, splits, rot, insect attack, sapwood, and warping.
- **Tools**: Hand lens, measuring tape, moisture meter (optional).
- **Process**: A trained inspector visually examines timber surfaces and cross-sections to classify them according to standard grading rules (e.g., IS 4970:2006).

1.2 Moisture Content Test

- **Standard**: IS 287:1993

- **Importance**: Timber strength is highly dependent on moisture content. Moist timber is prone to shrinkage, fungal attack, and lower mechanical performance.
- **Methods**:
  - **Oven Drying Method**:
    - A timber sample is weighed (W_1).
    - Dried in an oven at 103 ±2°C for 24 hours or until constant weight (W_2).
    - Moisture Content (%) = $\frac{W_1 - W_2}{W_2} \times 100$
  - **Electrical Resistance or Capacitance Meters**: For rapid, non-destructive measurements.

1.3 Specific Gravity and Density Test

- **Purpose**: Determines the weight-to-volume ratio, influencing strength and durability.
- **Process**:
  - Measure oven-dry weight.
  - Calculate volume using calipers or water displacement.
  - **Density** = $\frac{\text{Dry weight (g)}}{\text{Volume (cm}^3\text{)}}$
  - Reported in kg/m^3.

1.4 Compression Test Parallel to Grain

- **Standard**: IS 1708 (Part 1):1986
- **Purpose**: To determine the compressive strength along the grain direction.
- **Specimen**: Rectangular prism or cylindrical form (e.g., 50 mm × 50 mm × 200 mm).
- **Procedure**:
  - Load applied gradually using a UTM.
  - Failure pattern and crushing load noted.

- **Compressive Strength (σc)** = $\frac{\text{Maximum Load}}{\text{Cross-sectional Area}}$

1.5 Bending Test (Modulus of Rupture and Modulus of Elasticity)

- **Standard**: IS 1708 (Part 5):1986
- **Specimen**: Rectangular beam, typically 20 mm × 20 mm × 300 mm.
- **Testing Setup**: Three-point loading or four-point loading.
- **Parameters Evaluated**:
  - **Modulus of Rupture (MOR)**: $\text{MOR} = \frac{3WL}{2bd^2}$
  - **Modulus of Elasticity (MOE)**: $\text{MOE} = \frac{L^3 m}{4bd^3}$ Where,
    - W = load at failure,
    - L = span,
    - b = width, d = depth,
    - m = slope of load-deflection curve.

1.6 Shear Test

- **Purpose**: Measures resistance to shearing force parallel to grain.
- **Specimen**: Standard block with a notch.
- **Procedure**:
  - Load applied to cause sliding along the grain.
  - Shear Strength = $\frac{\text{Load at failure}}{\text{Area of shear plane}}$

1.7 Hardness Test

- **Standard**: IS 1708 (Part 7):1986
- **Method**: Janka or Monnin hardness test.
- **Procedure**: Steel ball pressed into wood surface.
- **Hardness**: Load required to embed the ball halfway into the wood.

1.8 Impact Test

- **Purpose**: Measures resistance to sudden shock or impact loads.
- **Apparatus**: Drop-weight or pendulum-based Charpy/Izod setup (adapted for wood).
- **Parameter**: Energy absorbed by the specimen before fracture.

2. Preservation of Timber

Timber preservation is a vital process to prolong the service life of wood by preventing or minimizing biological decay, weathering, and insect infestation.

2.1 Causes of Timber Decay

- **Biological Agents**:
    - Fungi (white rot, brown rot)
    - Insects (termites, beetles)
- **Environmental Factors**:
    - Moisture
    - Temperature
    - UV radiation
    - Chemical exposure

2.2 Objectives of Preservation

- Increase lifespan and durability
- Improve resistance to decay and insects
- Enhance dimensional stability
- Reduce maintenance costs
- Make non-durable species usable for structural work

2.3 Characteristics of an Ideal Preservative

- Non-leachable and long-lasting
- Non-corrosive to metals
- Non-toxic after fixation

- Deep penetrating
- Economical
- Compatible with adhesives, paints, and finishes

2.4 Types of Preservatives

A. Oil-Based Preservatives

- **Examples**: Creosote oil, Coal tar.
- **Advantages**:
  - High penetration and excellent resistance to moisture and fungi.
- **Disadvantages**:
  - Oily smell, unsuitable for indoor use or painted surfaces.

B. Water-Soluble Preservatives

- **Examples**: Copper-Chrome-Arsenic (CCA), Zinc chloride, Sodium fluoride.
- **Advantages**:
  - Less flammable, can be painted.
- **Disadvantages**:
  - Leachable if not fixed properly, requires pressure treatment.

C. Organic Solvent-Based Preservatives

- **Examples**: Pentachlorophenol in light oil.
- **Usage**: For utility poles, fencing, marine structures.

2.5 Methods of Timber Preservation

1. Surface Application

- **Method**: Brushing, spraying, dipping.
- **Use**: Temporary protection for indoor or dry condition use.
- **Limitations**: Shallow penetration.

2. Soaking or Dipping

- **Process**: Timber immersed in preservative tank for hours/days.
- **Used For**: Small timber elements, bamboo, poles.

3. Hot and Cold Process

- **Procedure**:

- Timber heated in hot preservative, then cooled in cold preservative.
  - During cooling, preservative gets sucked into wood pores.
- **Effective For**: Refractory species (dense hardwoods).

4. Pressure Treatment (Full-Cell and Empty-Cell)

- **Full-Cell Process**:
  - Vacuum applied to remove air.
  - Preservative injected under high pressure (7–14 kg/cm^2).
  - Deep penetration and high retention.
- **Empty-Cell Process**:
  - Air pressure used to retain less preservative.
  - Economical for large-scale treatment.
- **Standard**: IS 401:2001.

5. Boucherie Process

- **Method**: Suitable for freshly felled timber.
- **Procedure**: Preservative solution forced through one end of log, exits from the other.
- **Application**: Transmission poles, where rapid treatment is needed.

2.6 Seasoning Before Preservation

Preservation is more effective after seasoning, which removes excess moisture:

- **Natural Seasoning**: Air drying under shed.
- **Artificial Seasoning**: Kiln drying using controlled heat and humidity.

2.7 Fire Retardant Treatment

- **Need**: Timber is combustible; treatment reduces fire risk.
- **Process**:
  - Impregnation with salts like ammonium phosphate or borax.
  - Intumescent coatings applied to surface.

2.8 Safety Considerations

- Workers must wear PPE during treatment processes.
- Proper ventilation and disposal of preservative waste is necessary.
- Treated timber should not be used where it may contaminate soil or water supplies.

2.9 Advanced Timber Preservation Technologies

As construction standards evolve, modern technologies are being developed to enhance the efficiency and sustainability of timber preservation. These include innovative chemical formulations, nano-based treatments, and environmentally friendly alternatives.

2.9.1 Borate-Based Treatments

- **Chemistry**: Boron compounds (boric acid, borax) are diffused into timber.
- **Advantages**:
  - Effective against fungi, termites, and marine borers.
  - Low toxicity to humans and animals.
  - Retain timber's workability and finish.
- **Limitation**: Leachable in exposed environments; best for internal use.

2.9.2 Nano-Technology in Preservation

- **Approach**: Utilizes nanoparticles to carry biocides deep into wood fibers.
- **Benefits**:
  - Uniform distribution.
  - Better penetration in refractory species.
  - Long-lasting action with minimal environmental impact.
- **Status**: Emerging field under academic and industrial research.

2.9.3 Biodegradable and Eco-Friendly Preservatives

- **Need**: Traditional preservatives like CCA pose disposal and toxicity challenges.
- **Examples**:
  - Neem oil-based emulsions.

- Citrus-extracts and bio-polymers.

- **Application**: Low-load bearing structures, decorative items, furniture.

2.10 Durability Classification of Timber (IS 4873)

IS 4873 classifies timber based on its resistance to decay and insects:

Class	Expected Life (Years)	Examples
Very Durable	25+	Teak, Sal, Indian Rosewood
Durable	10–15	Deodar, Mahogany
Moderately Durable	5–10	Mango, Neem
Non-Durable	< 5	Poplar, Rubberwood

> Preservation is mandatory for timbers falling under moderately durable and non-durable classes when used in outdoor or ground-contact situations.

2.11 Field Performance Evaluation

After preservation, the actual field performance of timber must be monitored for:

2.11.1 Retention and Penetration Checks

- **Retention**: Amount of preservative in kg/m^3 of wood.
- **Penetration**: Depth of preservative penetration, verified via core sampling.
- **Testing Method**: Spectrophotometric or titration methods as per IS 401:2001.

2.11.2 Service Condition Monitoring

- **Methods**:
    - Periodic inspection for termite activity or fungal stains.
    - Moisture sensors embedded in timber.
    - Load-deflection monitoring in structural timber.

2.12 Indian Standards (IS) Relevant to Timber Testing and Preservation

IS Code	Title
IS 287:1993	Recommendation for Maximum Permissible Moisture Content in Timber
IS 1708 (Part 1 to 11)	Method of Testing Small Clear Specimens of Timber
IS 401:2001	Code of Practice for Preservation of Timber
IS 1141:1993	Specification for Seasoning of Timber
IS 4873 (Part I & II)	Specification for Hardwood and Softwood Sawn Timber for General Purposes
IS 303:1989	Specification for Plywood for General Purposes
IS 1902:2006	Code of Practice for Preservation of Timber by Pressure Processes

Following these standards ensures reliability, reproducibility, and regulatory compliance in construction projects.

2.13 Factors Affecting Effectiveness of Timber Preservation

Several environmental and processing factors influence how effective a treatment will be in the long term:

1. **Species of Timber**:
   - Porosity and sapwood/heartwood ratio affect absorption.
2. **Moisture Content**:
   - High MC prevents effective chemical absorption.
3. **Preservative Type**:
   - Oil-based offers better outdoor protection.
4. **Processing Method**:

- Pressure treatments yield deeper penetration than surface applications.

5. **End Use Environment**:
    - Ground contact, water immersion, or indoor exposure requires tailored approaches.

2.14 Practical Applications of Treated Timber

Application	Recommended Preservation
Railway sleepers	Creosote oil or CCA pressure treated
Transmission poles	Boucherie process or CCA
Marine piling	Oil-borne preservatives
Roof trusses, flooring	Borate treatment or solvent-based
Window frames, doors	Water-borne preservatives
Furniture	Seasoned, light preservative treatment

2.15 Limitations and Challenges

- **Toxicity and Handling**: Some preservatives (e.g., CCA) are carcinogenic and restricted in many countries.
- **Cost**: Pressure treatment facilities are expensive and not widely available in rural regions.
- **Leaching Risk**: In tropical climates, preservatives may leach during monsoon unless fixed.
- **Regulatory Constraints**: Environmental laws may restrict the use of certain chemicals.
- **Skilled Labour**: Inadequate training can result in uneven application and inefficacy.
