Guru Ghasidas Viswavidyalaya
Department of Forestry, Wildlife & Environmental Sciences
AR-7899
Programme: BSc Forestry (Fourth Semester)
Subject: **Wood Science & Technology**
Maximum Marks: 60

Note: Attempt any five questions. Question No.1 is compulsory and carries 20 Marks. Rest of the questions carry 10 Marks each.

1. (A) Multiple choice: Select the correct answers among the given options (2x3 = 6)

i. Cane & Bamboo Technology Centre (CBTC) is located in
   a. Kohima
   b. Imphal
   c. Guwahati
   d. Agartala
   Ans: (c) Guwahati

ii. The dependence of forest industries on fast grown plantation wood and non-traditional resources as the main source of raw material is
   a. Increasing
   b. Decreasing
   c. Constant
   d. Fluctuating
   e. None of above
   Ans: (a) Increasing

iii. Which physical characteristics of wood is very LESS useful in wood identification?

   a. Colour
   b. Density
   c. Lusture
   d. Taste
   Ans: (d) Taste

1 (B) Fill in the blanks with appropriate answers (2x7=14 Marks)

i. Pressure flow methods of wood preservation are also known as **bulk flow methods**

ii. Higher the chimney of wood seasoning kiln more rapidly will be **circulation of air.**

iii. Dry wood generally works, machines, finishes and glues better than **green timber/wood**

iv. **Hemicellulose** is the most hygroscopic chemical component of wood

v. Seasoning through soaking in hygroscopic substance is called **Chemical seasoning**

vi. **Softwoods** are more suitable for making pulp and paper due to the presence of long trachied fibers.

vii. Diledrin and lindane are **organic solvent** based wood preservatives

2. **Why study of seasoning and preservation are considered as wood technology not wood science? Give the reasons and also differentiate between wood science and wood technology. Also mention the traditional uses of wood.**

Answer: Study of seasoning and preservation are considered as wood technology not wood science because these are wood primary processing technologies based on applications of fundamentals of wood as material such as wood anatomy, wood chemistry, wood physics etc.

- These technologies utilize the knowledge of wood structure and its chemistry.
- Based on these technologies are optimized for the human applications.
- Knowledge of wood physics is critical for wood drying while study of biodegradtion of wood is vital for the wood preservation

Difference between wood science and technology

- Wood Science is that body of knowledge or fundamentals applicable to wood as a material, including its origin, properties, composition and characteristics. Eg. Wood anatomy, Wood Physics, Timber Mechanics, Wood Chemistry etc
- Wood Technology is the application of knowledge in the conversion, processing and the many uses of wood, including the design, manufacture and marketing of wood products. Eg. Wood seasoning, wood preservation, wood working, composite wood technology

Traditional uses of wood

- Wood is an important natural resource and a renewable material
- Traditional use of wood humans went into the forest and looked for the best suited tree (or part of a tree) for:
    - Burning and heating
    - Shelter, tent and house building
    - Ship building
    - Tools and weapons
    - Clothes and packaging
    - Art and religions
    - Medical use

3. Enlist physical characteristics of wood useful in wood identification. Discuss color and lusture of wood in detail with example.

Answer

- Number of physical characteristics can be useful in describing wood in macroscopic terms. such as
    1) color,
    2) luster,
    3) tactile properties,
    4) odor,
    5) taste,
    6) density and specific gravity,
    7) hardness,
    8) texture
    9) grain
- These characteristics can be detected simply by observing or handling a piece of wood.
- In few cases these characteristics can provide an immediate answer to identify a wood.

Colour of wood

- It is probably the first thing we perceive when we look a piece of wood.
- Distinctive color associated with many woods mainly results from deposition of extractives (tannins etc) in heartwood.
- Basic wood substance (cellulose and lignin) has little color of its own, thus, not affect the wood color significantly.

Factors affecting color of wood

- Heartwood or sapwood:
    - A dark color always indicates heartwood,
    - but a light color can be either a heartwood or sapwood
- Geographic location:
    - Same species may exhibit different color at different location.
    - Eg. Yellow poplar heartwood is generally of characteristics green color but in specific localities reported to be reddish brown to black color.
- Age of tree:
    - Freshly cut mahogany is light brown in color with pink cast. With age it turns deep reddish brown.
- Environment
    - Color is subjected to change with exposure to environment

- Eg heartwood of mahogany changes with time and action of light from reddish white to reddish brown.
- Long exposure of light-colored woods to the sun, changes their color to brown; whereas long exposure to rain or high humidity changes them to dark grey.

- Bio-degradation
  - Color change is also affected by bacterial or fungal attack eg. Brown rot
- Wood treatments
  - Natural color of wood can be preserved by transparent finishes
  - Colour may be changes artificially by dyeing, bleaching, heat-treatment, steaming.
- Perception of color
  - It is different to different people: terms like deep red-brown, light olive brown mean different things to different people.
  - Thus, it is useful to have a reference collection of wood samples to compare with written description of wood colors.
- Some woods are known for its distinctive color

Lusture

- It is a measure of light reflection.
- It varies among species and also varies with grain direction in a single sample.
- It may be useful in identification in some cases.
  - Eg. Among softwoods, spruce is noted for its lustrous longitudinal surfaces which helps to separate it from white pine or true firs, with which it is often confused.
  - Ash, sycamore, basswood and poplar are also among lusterous wood.
  - On contrary surfaces of some woods feel greasy such as bald cypress, teak, olive and lignum vitae.
- Within a species, radial planes often shows greater luster than tangential planes due to collective contribution of ray surfaces.
- Some of the decorative figures are also result of difference in lusture associated with variable grain direction.
  - Eg. ribbon or strip, blister, quilted, fiddleback figure and many other distinctive wood patterns result in large measure from variable lustre

4. **Determine the strength (MOR) and stiffness (MOE) of babul wood in a static bending test using following data: breadth of the test specimen (b) = 2 cm; depth of the test specimen (h) = 2cm; supporting span (L) = 30cm; maximum load when the bean is broken (Pmax) = 10kN ; load in N within the proportional deflection (P) = 7.5 kN; Δ is the deflection at mid-length below the proportion deflection limit (Δ) = 0.35cm**

Solution:

P= 7.5kN=7500N; Pmax = 10kN=10000N;

L= 30cm= 300m,

b=2cm=20mm;

h=2cm=20mm

Δ=0.35cm=3.5mm

$$MOE = \frac{P \cdot L^3}{4\Delta \cdot b \cdot h^3}$$

MOE = 7500 x 300 x 300 x 300 / 4 x 3.5 x 20 x 20 x 20 x 20 = 562.5 N/mm2 (Pa)

$$MOR = \frac{3P_{max} \cdot L}{2b \cdot h^2}$$

MOR = 3 x 10000 x 300 / 2 x 20 x 20 x 20 = 90401.79 N/mm2 or Pa = 9.04 GPa

5. What is dielectric constant? Explain the factors affecting dielectric constant of wood.

Answer

- Dielectric constant : it is one of the measure of insulating capacity of a material under alternating current. Moisture content of wood can be measured with moisture meters, which determine dielectric constant rather than electrical resistance. This method has the advantage over dc resistivity meters in

that the readings are not affected by an ash or mineral content. However, reading must be corrected for density of the wood.

- Factors affecting dielectric constant: In wood the dielectric constant mainly varies directly with
  - moisture content: Oven dried wood is non-conductor; Dielectric constant increases with increasing moisture content
  - Applied electric field: K decreases slowly with increasing frequency of the applied electric field.
  - Temperature: increases with increase in temperature
  - Grain direction: In dry wood the dielectric constant is 1.3 to 1.5 times greater in the longitudinal direction than it is in the transverse direction.

6. What are the main principals of seasoning? Explain kiln seasoning with its advantages and disadvantages

Answer:

- Seasoning is the controlled process of reducing the moisture content (MC) of the timber so that it is suitable for the environment and intended use. It constitutes one of the most important steps in converting raw wood into finished products.

Principals of seasoning

The main principal of seasoning is to control the rate of drying and regulating it with in limit so that the wood seasons with least possible damage or minimum defects. Free water is removed first during seasoning since energy needed to break hygroscopic bonds is fully utilized evaporating free water from the wood surface There are three factors which control the rate of drying:

1. Heat
2. Humidity of air
3. Circulation of air around the timber

1. Heat (Temperature of circulating air)

- Heat is used in drying to produce rapid surface evaporation of water
- The source of heat is atmospheric temperature in air seasoning and steam in all types of kilns except solar kilns
- Steam is cheap source heat compared to gas and electricity, easily and safely controllable; no fire risk.
- Hot combustion air is used if steam is not available

2. Humidity of air

- Relative humidity: Ability of air to dry any substance varies with amount of moisture it can hold before getting saturated the amount of moisture (water vapour) in the air at a given temperature, compared with the maximum amount of moisture the air could hold at the same temperature
- Humidity in kiln can be increased by spray of steam, hot water etc and reduced by cold water spray/cold water condensers which condenses the water vapour when the temperature of water is below dew point.

3. Circulation of air

- Rapidity of seasoning depends upon the amount of circulation of air in timber stack.
- Circulation of air is produced by chimney flues due to natural draft caused by difference in outside and inside temperature. Higher the chimney more rapidly will be the circulation.
- It may also produced by heating coils.
- The best method for circulation is by centrifugal fans and blowers which may placed at the top or side of the kilns.

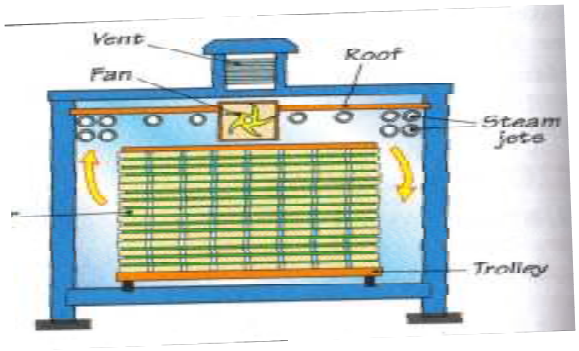
Kiln Seasoning

- There are two main types of kiln used in artificial seasoning
    - ☐ Compartmental Kilns
    - ☐ Progressive Kilns.
- Both methods rely on the controlled environment to dry out the timber and require the following factors:
- Forced air circulation by using large fans, blowers, etc.
- Heat of some form provided by piped steam.
- Humidity control provided by steam jets.
- The amount and duration of air, heat and humidity again depends on species, size, quantity, etc. In general, the atmosphere in the kiln at first will be cool and moist. The temperature is gradually increased and the humidity reduced until the required moisture content is achieved.

- Drying Schedules are published for the various species to enable operators to select an appropriate drying environment

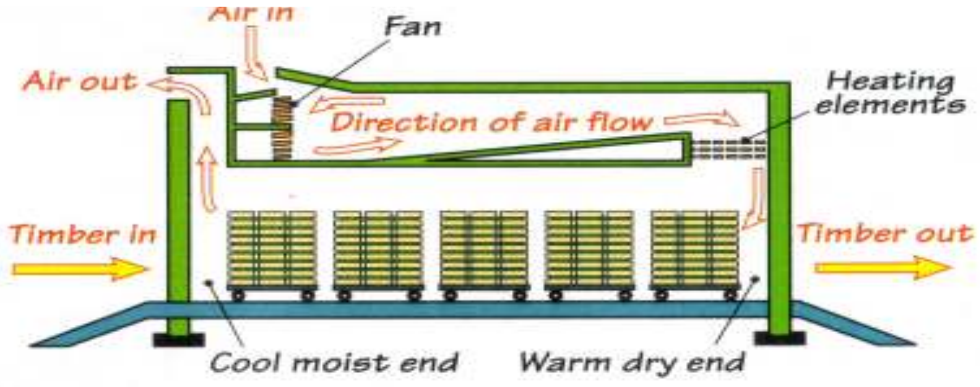
Compartment Kiln

- This kiln is a single enclose container or building, etc.
- The timber is stacked same manner as air seasoning
- Whole stack is seasoned using a programme of settings(temperature and humidity) until the whole stack is reduced to the MC required.



Progressive Kilns

- A progressive kiln has the stack on trolleys that 'progressively' travel through a sequence of chambers.
- Each chamber has varying atmospheres that change the MC of the timber stack as it travels through.
- Advantages of this system- has a continuous flow of seasoned timber coming off line



Kiln seasoning

- **Advantages**

- ☐ Quicker due to higher temperatures, ventilation and air circulation
- ☐ Achieve a lower moisture content
- ☐ Defects associated with drying can be controlled
- ☐ Allows more precise rates of drying for various timber species and thickness of boards

- **Disadvantages**
  - ☐ Is expensive
  - ☐ Requires supervision by a skilled operator
  - ☐ Uses a lot of energy

7. Which are the main abiotic and biotic degrading agents of wood ? What are non-pressure methods of wood preservation?

Answer

- Decay or Degradation of wood is alteration in its structure and chemistry due to external agents (plant, animal or non-biotic)
- Such degradation varies from simple discoloration of wood to complete decomposition making it totally useless

Wood decaying agencies can be divided into:

- Abiotic degradation agencies: Degradation of wood as a result of prolong action of abiotic factors such as
  - Climatic
  - Mechanical
  - Chemical
  - Thermal
- Biotic Degradation agencies Wood may be reduced to its component through attack by organisms such as
  - Plant:

- Bacteria
- Fungi
    - Discolouration or spoilage fungi
        - Mold Fungi
        - Stain Fungi
    - Decay Fungi
        - Brown rot fungi
        - White rot fungi
        - Soft rot fungi

- Animals: insects, termites, marine organisms
    - Most important and common animals are
        - Insects
            - Termites (order *Isoptera)*
            - *Wood Boring Beetles (order Coleoptera)*
        - Marine borers
            - Molluscs
            - Crustaceans
        - Less important (*significant* locally only)

            wood wasps, moths, carpenter ants *etc*

Non-pressure methods

- Wood can be protected by degradation agents by applications of toxicants to achive a long and predictive life. Preservatives are applied by **bulk flow** (Pressure Methods) and/or **diffusion** (Non pressure Methods). Non pressure methods are simple methods which do not involve application of intense pressure, vacuum and temperature.
- The main non-pressure methods are
    1. Steeping Methods
        - Examples Brushing, Spraying, Dipping
        - Short term protection.

- Water repellent can be add for dimensional stability.

2. Diffusion Methods

- Used for treatment of green timber with water soluble preservatives.
- Free water of wood cells aids in preservative penetration through a concentration gradient.

3. Sap displacement Methods

- Involve flow of preservative solution along the length of wood and along the flow of sap stream.
- Timber is placed vertically or partially inclined in water soluble preservative solution for 3-4 days after which timber is inverted and allow to stand for same period.

8. Explain (Any two)

a. Circular and band saw

Circular saw

- a saw with a circular blade which spins. A circular saw is used to make clean, straight, fine saw cuts. It can be attached to a benchtop or handheld.
- Circular saws can be large for use in a mill or hand held up to 24" blades and different designs cut almost any kind of material including wood, stone, brick, plastic, etc

Band saw

- A bandsaw is a power tool which uses a blade consisting of a continuous band of metal with teeth along one edge to cut various workpieces.
- The band usually rides on two wheels rotating in the same plane,
- Bandsawing produces uniform cutting action as a result of an evenly distributed tooth load.
- Bandsaws are used for woodworking,
- Timber mills use very large bandsaws for ripping lumber; they are preferred over circular saws for ripping because they can accommodate large-diameter timber and because of their smaller kerf (cut size), resulting in less waste.
- Head saws are large bandsaws that make the initial cuts in a log.
- A resaw is a large bandsaw optimized for cutting timber along the grain to reduce larger sections into smaller sections or veneers.

b. Bamboos and canes

- In the Indian forestry sector, bamboo, which is referred as minor forest produce in classical forestry, is the most important NTFP

- Bamboos and cane Potential for different value added products and application makes them an extremely important material for dispersed economic activities. Both have a good future ahead.
- Advantages
- They are fast growing, wide spread, versatile, multiple use, renewable and low cost natural resources
- Bamboo is one of the most abundant and renewable resources available .Bamboo, being a source of raw material to many industries such as pulp and paper, rayon, and fiberboard industry, has been critical in the forest-based industrial development in India.
- Also known as Green Gold, Poor man timber due to its multiple use and easy accessibility.
- India is the second richest bamboo resource country in the world, next only to China. India has 30% of the world's bamboo resources The total bamboo growing area of 14 million ha. The state of Arunchal Pradesp has the highest bamboo bearing forest area of 1.6 m hectares followed by MP
- In terms of genetic diversity, India has 136 bamboo species under 75 genera.
- Cane and bamboo belong to disparate botanical families, have different properties, and are propagated and grown in dissimilar ways.

Bamboo	**Cane/Ratton**
Poaceae/Gramineae	Palmaceae
Aks Green gold/poor man timber	Aks Rattan
It is grass	It is a climber
Typicall hollow cylinder	Solid stem
Bamboo grows easily, and very quickly in range of envrinment	Cane is a climber, requires a secluded environment, and has long gestation periods.
All the parts are useful	Mainly stem is used

c. Refractory and non-refractory behavior of wood

The timbers are classified as follows according to their ease of drying and their proneness to drying degrade:

1. Highly refractory woods

    - These woods are slow and difficult to dry if the final product is to be free from defects, particularly cracks and splits.
    - They require considerable protection and care against rapid drying conditions for the best results
    - Examples are heavy structural timbers with high density such as eucalypts, mahua, tendu, jamun, sal, anwala etc

2. Moderately refractory woods

    - These timbers show a moderate tendency to crack and split during seasoning.

- They can be seasoned free from defects with moderately rapid drying conditions (i.e. a maximum dry-bulb temperature of 85 °C can be used).
- Examples are babul, siris, shisham, gamari, teak, neem, arjun and other timbers of medium density (Bootle, 1994), which are potentially suitable for furniture.

3. Non-refractory woods

- These woods can be rapidly seasoned to be free from defects even by applying high temperatures (dry-bulb temperatures of more than 100 °C) in industrial kilns.
- If not dried rapidly, they may develop discolouration (blue stain) and mould on the surface. Examples are softwoods and low density timbers such as fir, semul, deodar, mango, spruce, pine