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Model Answer
AR-7279
Programme: MSc Forestry (Second Semester)
Subject: **Wood Properties: Seasoning and Preservation**
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. Bamboo is
   a. Softwood
   b. Hardwood
   c. Both
   d. None of above
   Ans: (d) None of above

ii. Example of water based preservative is
   a. Creosote
   b. CCA
   c. PCP
   d. All of above
   Ans: (b) CCA

iii. Electrical moisture meter is useful in determining moisture of wood:
   a. Above FSP only
   b. Below FSP only
   c. Both above and below FSP
   d. None of above
   Ans: (b) Below FSP only

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

i. **A progressive kiln** has the stack on trolleys that travel through a sequence of chambers.

ii. **Bowing** is defect is indicated by curvature formed in direction of length of timber

iii. Various radial and circular cracks develop in the interior portion of timber, due to stresses developed during drying is termed as **shakes**

iv. Wood tissues of softwoods are mainly composed (90-95% of volume) of **trachieds**

v. Hardness is defined as resistance to **indentation**

vi. The most destructive wood destroying biological organism is **fungi**

vii. The wood destroying beetles mainly belong to order **coleopteran** of insects

2. What are softwoods and hardwoods? Compare the main structural and function difference between hardwoods and softwoods.

- Softwoods: Wood produced by one of the botanical groups of trees that in most cases have needlelike or scalelike leaves. They are also known as conifers. Eg. Pines, spruces, firs. Normal softwoods has

OD density 30lb/cft Scot pine, douglus fir. However there are many exceptions: Pitch Pine, Yew (OD density 42-48 lb/cft). Thus, the term has no reference to the actual hardness of the wood.

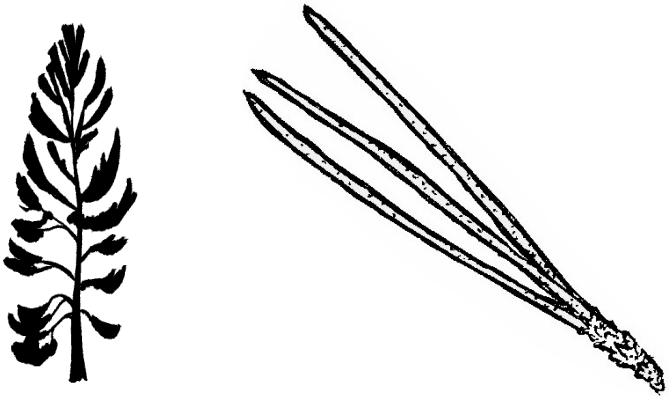


Fig Softwood tree and needle shape leafes

- Hardwoods: Wood produced by one of the botanical groups of trees that have broad leaves. They are also called A*ngiosperms* or *Deciduou*.Normal hardwoods (Average OD density 45lb/cft) Teak, Oak, Walnut, Eucalypts. But there are many exceptions:Cricket willow, Aspen (25-28lb/cft) ,Balsa (8lb/cft) Lightest wood; Lignum vitae (80lb/cft) Hardest wood. Thus it is a misnomer

Fig Hardwood tree

Difference between softwood and hardwood

Structural differenc		
	Softwoods	Hardwoods
	• Overall structure is simple and uniform • No vessel elements	• Structure is complex and varying in nature • Vessel elements are unique

	• Rays are mostly uniseriate. • Proportion of ray to total xylem is less • Straight radial rows of cells • Softwood trachieds are longer (3-4 mm) in length. • Cell composition: Longitudinal trachieds: 90-95%; Ray cells 4-9% and Other cells: 0-2 %	feature • Ray width vary from 1-30 cells. • Rays constitutes average 17 % of xylem volume (can be up to 30%) • Hardwood cells are seldom aligned in straight radial rows due to vicinity of large vessel element. • Hardwood fibers are shorter (< 1mm) • Cell composition: Vessel element: 20-60%; Fiber trachied: 15-60%; Longitudinal parenchyma: 0-24% and Ray cells: 5-30 %

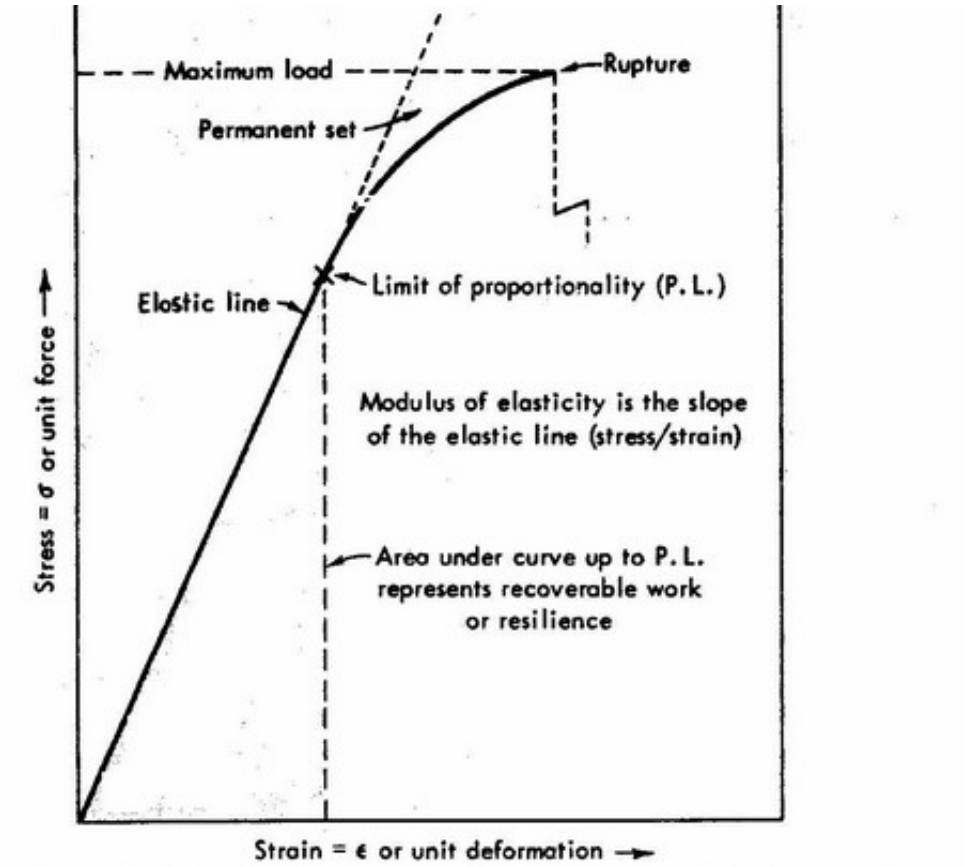
Functional difference:

Function	**Softwood**	**Hardwood**
Conduction	Longitudinal trachied	Vessel element
Support	Longitudinal trachied	Fibers
Storage	Ray parenchyma	Ray parenchyma

3. Explain whether wood is plastic or elastic material? Explain with diagram and define elastic limit and ultimate stress.

Answer

- The degree of deformation a piece of wood will undergo, is proportional to the amount of load applied.
- Elasticity implies that deformations produced by low stress are completely recoverable after loads are removed.
- Wood is elastic up to a point, called the elastic or proportional limit. Applied stress at the elastic limit is known as fiber stress at elastic limit



Idealized load-deformation diagram for static loading to failure.

- Stress (applied load) and strain (deformation) at elastic limit is used to determine modulus of elasticity.
- Modulus of Elasticity (MOE) is a measure of the ability to bend freely and regain normal shape.
- If loads are applied below the elastic limit and then removed, the wood will go back or spring back to its original shape.
- However, when load is at higher stress levels, plastic deformation occurs.
- If a load is applied that exceeds the elastic limit and is then removed, the wood will go back only partially to its original shape.
- This is because the load applied was too much for the wood to stand and damage to the wood occured.
- If the applied load is very, very high, the wood is no longer able to support this high load and the wood breaks. Applied Stress at breaking point is known as Ultimate stress.
- Thus, Ultimate stress or Modulus of rupture or rigidity (MOR) is a measure of the resistance to failing. It reflects the maximum load carrying capacity of a member in bending
- Modulus of rigidity (MOR) is also called shear modulus
- It is an accepted criterion of strength,
- Thus, wood behaves in an elastic manner up to a point called the elastic or proportional limit
- This means that for values of load below the elastic limit, the load and deflection are proportional to each other.
- Once the load level passes the elastic limit, the load and deflection are no longer proportional.

4. **What do you understand by SG and density of wood? Calculate the specific gravity of a wood sample with following data: mass of wood 4.20 kg and volume of wood specimen: 8000cucm**
   Answer

- Density is mass contained in unit volume.
- Measurement units of density
  - g/cm^3 (CGS)
  - kg/m^3 (MKS)
  - lb/ft^3 (FPS).
- Specific gravity (relative density) is the ratio of density of material to the density of water.
- Density of water
  - 1 g/cm^3 (CGS) or
  - 1000 kg/m^3 (MKS) or
  - 62.4lb/ft^3 (FPS)
- If density is measured in g/cm^3 then value of the specific gravity is the same that of density.
- Wood with specific gravity >1 will sink in water while those with specific gravity <1 will float in water.
- To avoid the effect of weight of water in the wood we use oven-dry weight for standard measurements of density and volume is measured at specific moisture content (oven-dry, air dry 12 % moisture content or green wood) .
- The situation is not so simple with wood because changes in moisture content affect both its mass and volume.
- Therefore it is necessary to specify moisture content of wood while determining density.

➢ Density at X% moisture content = $\frac{\text{Mass of wood at x \% moisture content}}{\text{Volume of wood at x \% moisture content}}$

➢ *Oven - dry density* = $\frac{\text{Oven - dry mass of the wood}}{\text{Oven - dry volume of the wood}}$

➢ *Air - dry density* = $\frac{\text{Mass of wood in equilibrium with atmospheric conditions}}{\text{Volume of wood in equilibrium with atmospheric conditions}}$

➢ *Green density* = $\frac{\text{Mass of the wood when green}}{\text{Volume of the wood when green}}$

Calculation of specific gravity

a. Mass of wood 4.20 kg = 4.2 x1000= 4200gm
b. Volume of wood specimen: 8000cucm

   Density of wood = 4200/8000

   = 0.525 gm/cm^3

   In density is calculated in CGS system then density of wood and specific gravity will be the same

   Thus Specific gravity of the wood sample is = **0.525**

5. Define thermal insulating value, electric resistivity and dielectric constant of wood. Briefly explain behavior of wood in fire.

Answer

- Thermal insulating value of wood: It is the reciprocal of the thermal conductivity.
  - R=1/K.
  - Thus, the insulating value for wood is inversely proportional to the specific gravity and moisture content.
  - This relationship explains the use of low-density and dry wood eg. balsa wood (*Ochroma lagopus* Sw.) for insulating purposes.
- Electrical resistivity of a material determines its ability to resist the flow of electric current when the material is placed under a given voltage gradient. Air dried wood is an excellent insulator of electricity with the resistivity of about 10^{14} to 10^{16} ohm·m
- Dielectric constant : it is one of the measure of insulating capacity of a material under alternating current . In wood the dielectric constant mainly varies directly with moisture content; Applied electric field; Temperature and Grain direction.

Behaviour of wood in fire

- In fire performance of wooden construction is better than steel and it maintain their strength during fires,
- Large wood members burn slowly and only when there is a continuous external heat supply.
- Furthermore, the low thermal conductivity of the wood delays the weakening effects of the elevated temperatures on the unburned interior
- After a fire the wood members, if of sufficient thickness, will have a shell of charcoal over the surface, but the member may still support the loads for which it was designed.

6. Which are the main abiotic and biotic degrading agents of wood ? Discuss characteristics of an ideal wood preservative.

- 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*

Characteristics of an ideal wood preservative:

1. Effectiveness/toxicity against target organism such as insect fungus
2. Low human and animal toxicity, safe for workers, consumers etc
3. Penetration capacity: Easy to penetrate in wood over the entire cross-section
4. Uniform Distribution in the wood
5. Good Fixation capacity: Easy to fix in wood
6. Retention capacity: minimum leaching in soil and water
7. High stability during treatment for treatment temperature
8. Eco friendly: No Soil, marine and river pollution
9. No objectionable colour or odour
10. Can be painted or finished or glued
11. Easy Availability
12. Safe and easy to transport
13. No fire hazard
14. Economical to use
15. No corrosion to metals in use
16. Easy to dispose after the end of service-life

7. Why it is critical to dry the wood? Explains advantages and disadvantages of air and kiln seasoning.

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.
- Prompt drying of wood immediately after felling therefore significantly upgrades and adds value to raw timber. Drying enables substantial long-term economy by rationalizing the use of timber resources. The main advantages of wood drying are
  1) It in parts dimensional stability
  2) seasoning reduces gross weight and thereby subsequent reduces shipping and handling costs,
  3) It increases most strength properties,
  4) increases fastener holding power and thereby joint strength,

5) Timbers for impregnation with preservatives have to be properly dried if proper penetration is to be accomplished, particularly in the case of oil-type preservatives.
6) In the field of chemical modification of wood and wood products, the material should be dried to certain moisture content for the appropriate reactions to occur.
7) Dry wood generally works, machines, finishes and glues better than green timber. Paints and finishes last longer on dry timber.
8) The electrical and thermal insulation properties of wood are improved by drying.
9) Prevents attack by wood destroying agents such as fungus and insects.

Advantages and disadvantages of air seasoning

Advantages

- No expensive equipment needed
- Small labour cost once stack is made
- Environmentally friendly- uses little energy

Disadvantages

- Slow drying rate
- Large area of space required for a lot of timber
- Only dries the timber to approximately 20% M.C. so leaving it open to some insect and fungal attacks while it is only suitable for outdoor joinery

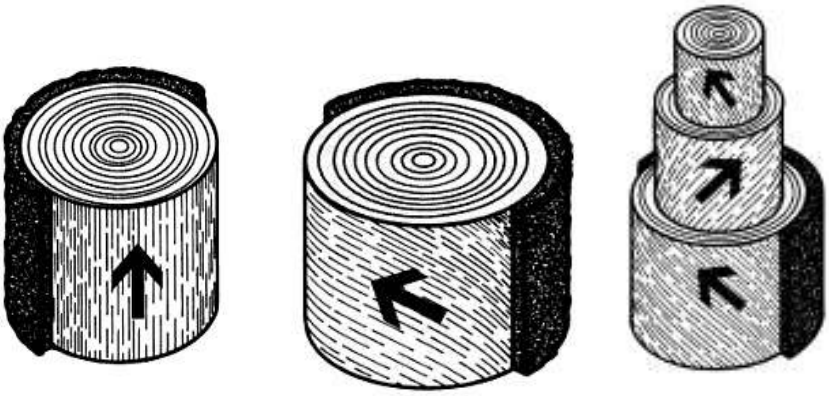
Advantages and disadvantages of Kiln seasoning

- **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

8. Explain (Any two)

a. Grain deviation

- Fibers are normally oriented with their length essentially parallel to the long axis of the stem. However, in several cases, fiber are oriented at a slight angle to the stem axis.
- Thus, grain orientation is the direction of most of the long tapered wood fibers in relation to the long axis of stem.
- It can significantly affect wood properties.
- Types of grain orientation
    - Parallel grain:
        - Wood fibres are parallel to the long axis of stem
        - Easy to work
        - Normal mechanical properties
    - Spiral grain
        - Wood fibers are spirally arranged about the stem axis
        - When logs exhibiting spiral grain are sawn, the lumber formed has a grain direction that is not parallel to the board length.
        - Such lumber is said to have slope of grain; it is typically low in strength and stiffness and may tend to twist as it dries
        - Planning of such lumber to a high-quality surface may also be difficult
    - Interlocked grain
        - In some trees (Sal, Elm), grain may spiral in one direction for several years and then reverse direction to spiral oppositely.
        - Wood produced in this way is said to have interlocked grain.
        - Woods with interlocked grain are high in strength but difficult to split and work
        - Wood with this characteristic may also shrink longitudinally upon drying, warp
        - Occurrence of interlocked grain is occasionally considered desirable from an appearance standpoint.

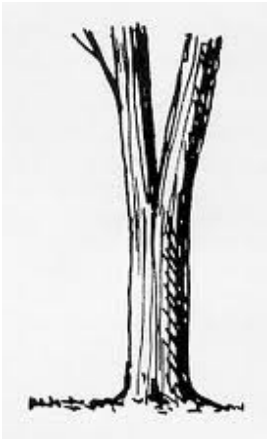


Parallel grain Spiral grain Interlocked grain

b. Fork and crook

FORK

- A fork results from the division of the main stem into two or more stems at any point above the root collar.
- The degrading effect is greatest in the portion of the stem where the division occurs.
- In the forked portion, both the grade outturn and volume yield of any product are reduced significantly.
- In veneer logs, including a fork disqualifies the log for veneer production.
- In factory logs, a fork markedly reduces both the lumber grade and volume yield and is a log grade defect for which a log-scale deduction must be taken.
- In construction logs, the fork and twin stems are not permitted



Forking

Crooking

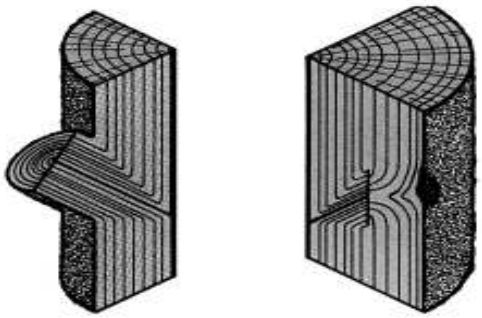
CROOK

- A tree defect characterized by a sharp bends in the main stem.
- They are abnormally twisted from the main axis.
- This abnormality some time create aesthetic appearance in tree stand

- It may also create attractive figure or structural pattern in sawn wood
- However, such wood is very difficult to work and have significant growth stresses
- some time used as such as decorative piece

c. Knots

- Knots are portions of branches included in the wood of the stem or larger branch
- A knot is a defect in a piece of wood caused by the presence of a branch.
- In grading knots are classified according to their form, size, soundness, and the firmness with which they are held in place.
- Knots affect
    - checking (cracking) and warping,
    - difficulty in working and cleavability of timber.
    - They are defects which weaken timber and depreciate its value for structural purposes where strength is an important consideration.
    - The weakening effect is much more serious where timber is subjected to bending and tension than under compression.
    - The extent to which knots affect the strength of a beam depends upon their position, size, number, direction of fiber, and condition.
    - However, in some cases, knots increases the aesthetic value of board/veneer



Knots