THE UNIVERISTY OF ZAMBIA

School of Engineering

Department of Civil and Environmental Engineering

CEE 3111 - CIVIL ENGINEERING MATERIALS AND CONSTRUCTION PRACTICES

2023 ACADEMIC YEAR

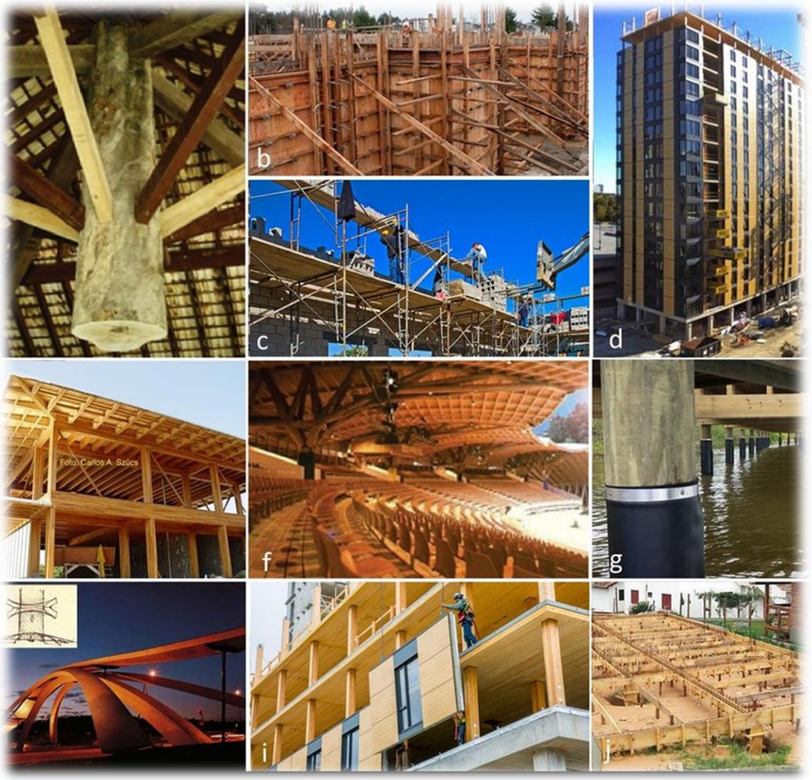
SEMESTER 1

TOPIC 5

Timber as a construction material

Introduction

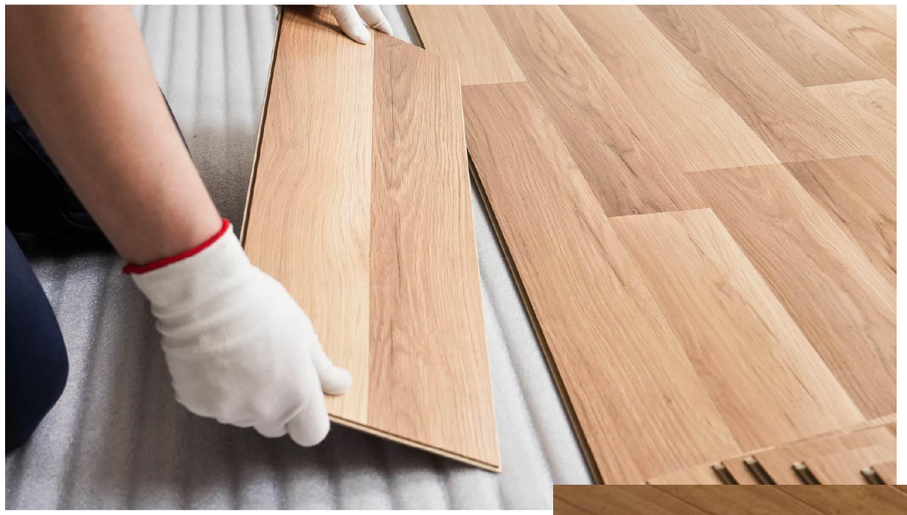
- Wood continues to be an important civil engineering material because of its;
  - ✓ availability,
  - ✓ relatively low cost,
  - ✓ ease of use, and
  - ✓ durability (if properly designed),
- Uses:
  - ✓ buildings,
  - ✓ bridges,
  - ✓ utility poles,
  - ✓ floors, roofs,
  - ✓ trusses, and piles.



- Civil engineering applications include both natural wood and engineered wood products, such as laminates, plywood, and strand board (flakeboard).

Introduction

Laminated Floor



Ceiling

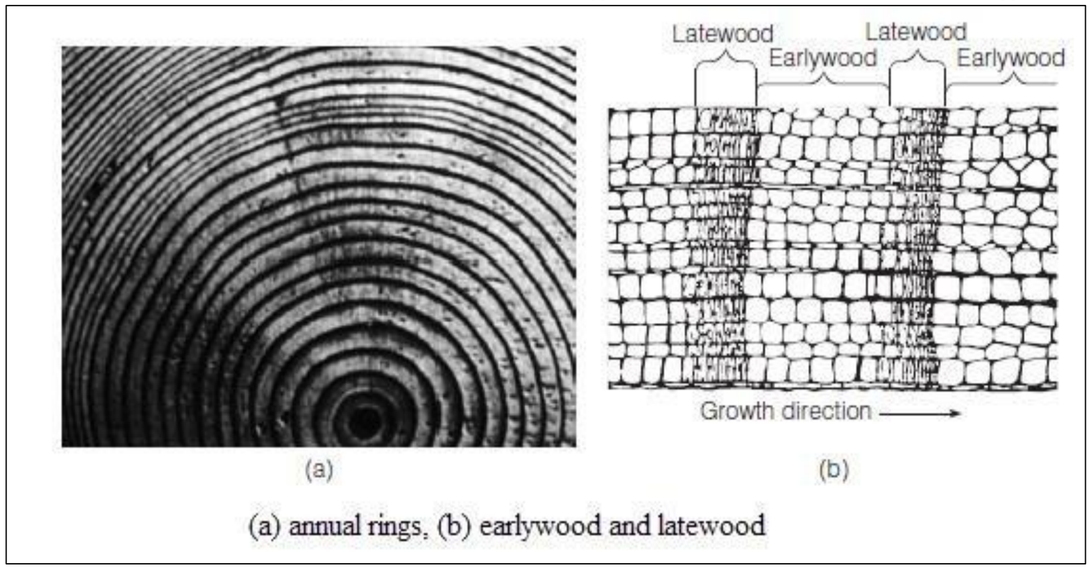
Strand board

Structure of wood

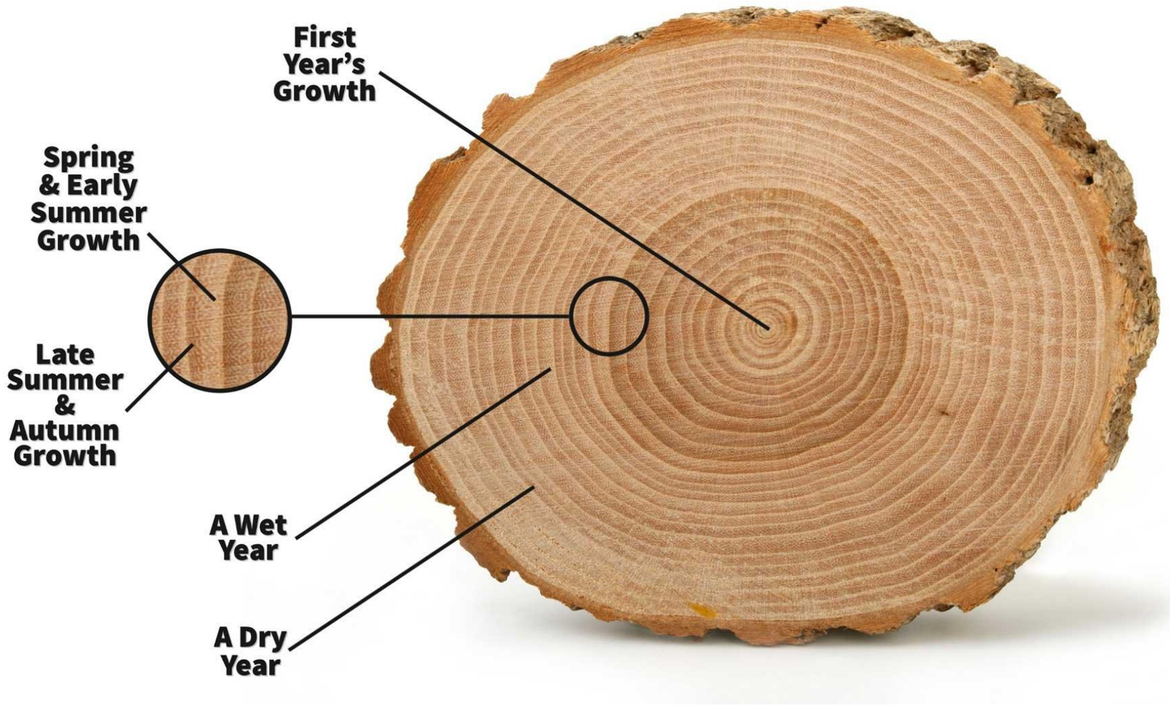
Growth Rings

- Wood has a distinct structure that affects its use as a construction material

- The concentric layers in the stem of exo are called growth rings or annual rings.



(a) annual rings, (b) earlywood and latewood

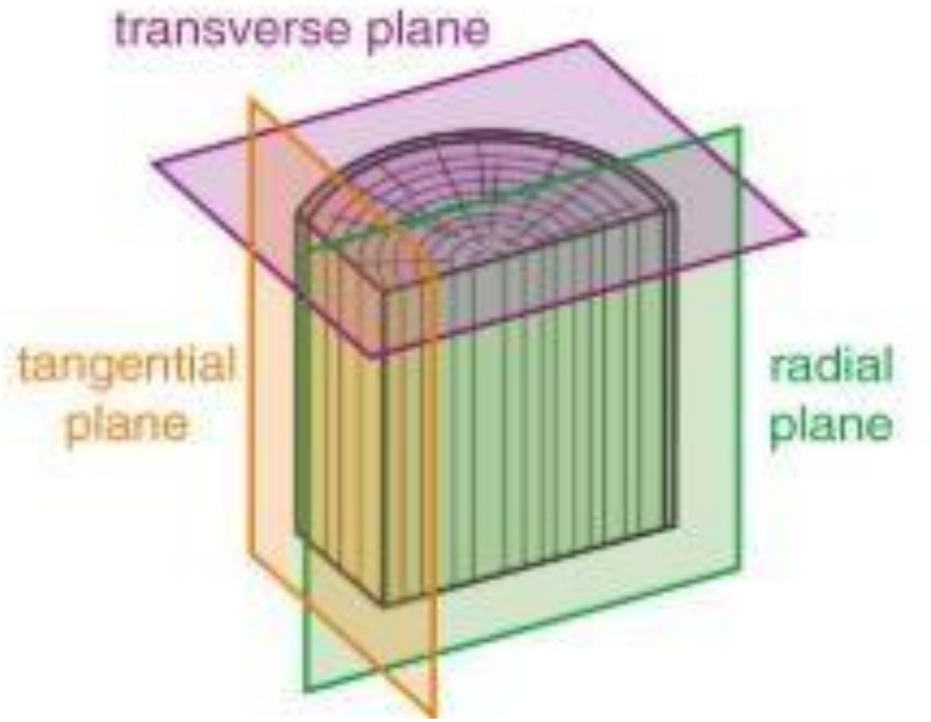


Structure of wood

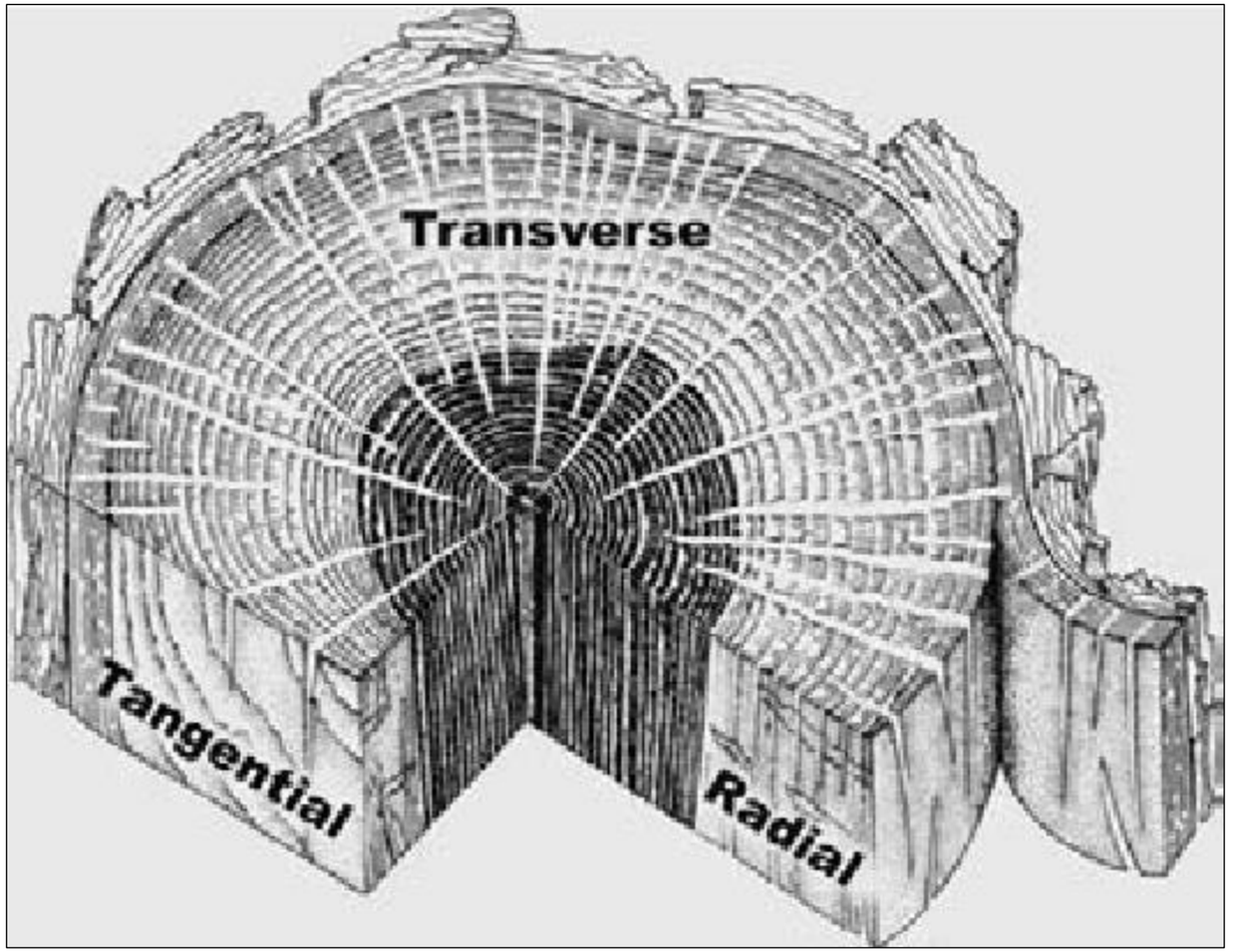
Anisotropic Nature of Wood

- Wood is an anisotropic material in that it has different and unique properties in each direction

- The three axis orientations in wood are:
  - ✓ longitudinal, or parallel to the grain;
  - ✓ radial, or cross the growth rings; and
  - ✓ tangential, or tangent to the growth rings



Structure of wood



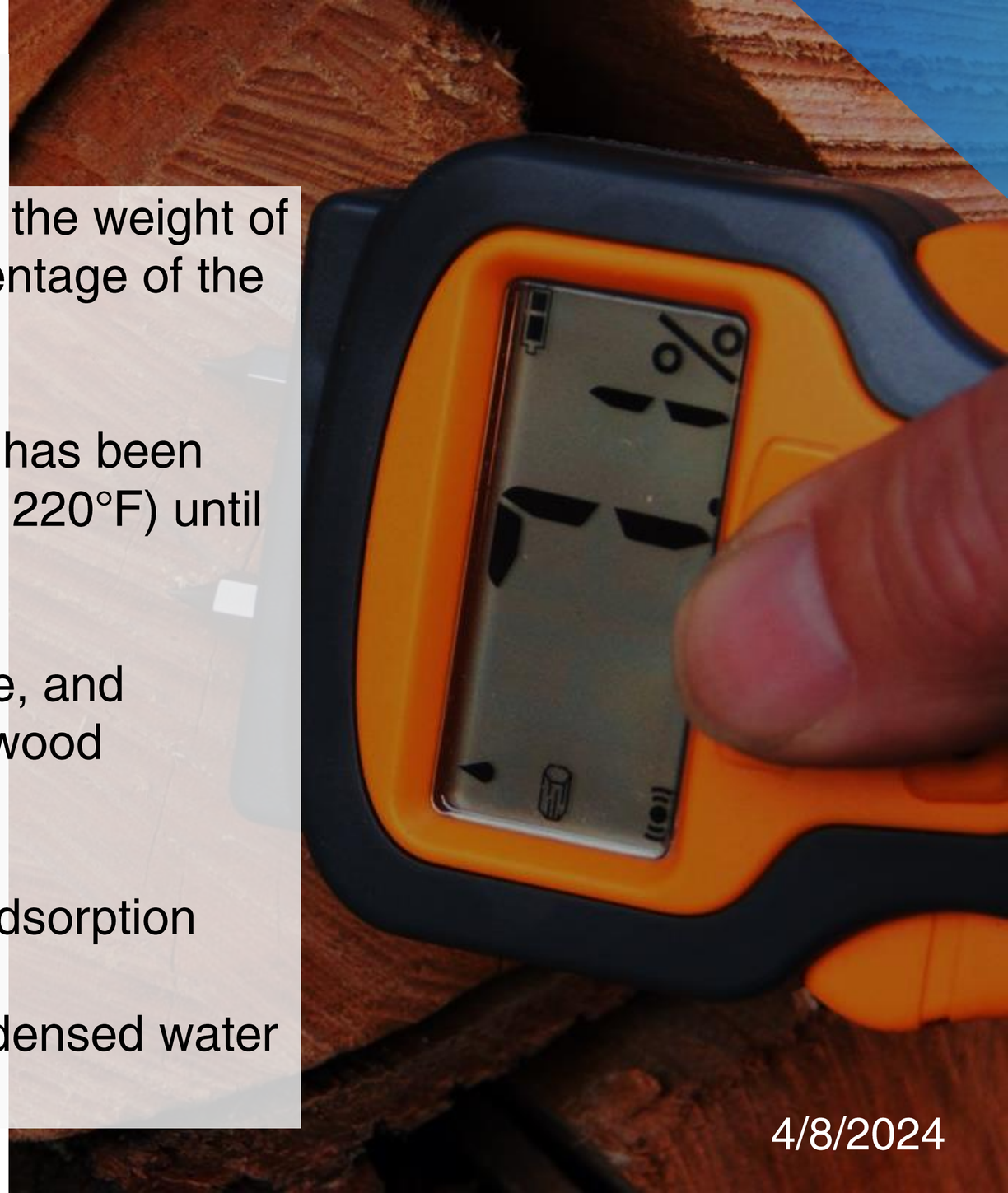
Moisture Content

- The moisture content of a wood specimen is the weight of water in the specimen expressed as a percentage of the oven-dry weight of the wood

- An oven-dried wood sample is a sample that has been dried in an oven at 100°C to 105°C (212°F to 220°F) until the wood attains a constant weight.

- Physical properties such as weight, shrinkage, and strength depend on the moisture content of wood

- Moisture exists in wood as either:
  - ✓ bound - water held within the cell wall by adsorption forces
  - ✓ free water - water that exists as either condensed water or water vapor in the cell cavities.



Moisture Content

- At the fiber saturation point (FSP), cell walls are entirely saturated but cell cavities are dry.
- FSP ranges from 21% to 32% between species and within species.
- The FSP is important because moisture below the FSP affects almost all wood physical and mechanical characteristics, whereas above it, they are independent of moisture.
- Dimensionally stable wood has moisture above the fiber saturation point.
- However, moisture below the FSP always alters dimensions. Swelling is induced by cell wall moisture gain, while shrinkage is caused by moisture loss.

Production of wood

Click here to see video

Wood cutting techniques

Seasoning

Controlled technique that removes excess wood moisture.

For structural wood, the recommended moisture content varies from 7% in the dry states to 14% in the damp regions

Wood is seasoned by air and kiln drying

Air drying is inexpensive, but slow

After air drying the lumber may be kiln dried

A kiln is a large oven where all variables can be closely monitored

Drying too rapidly can result in an increase in cracking and warping.

Dried lumber will take on moisture again if exposed to water; therefore, care must be used when storing and transporting wood

Structural lumber is not typically air-dried prior to kiln drying

Wood cutting techniques

Surfacing (Planing)

- This is the planing of the wood surface to produce a smooth face
- It can be done before or after drying.
- Post drying surfacing is superior, because it removes small defects developed during the drying process.
- When surfacing is done before seasoning, the dimensions are slightly increased to compensate for shrinkage during seasoning.

Grading of wood

- Involves grading the lumber according to quality.
- Typically, lumber is graded according to the characteristics that affect strength, durability, or workability.
- The most common grade-reducing qualities of lumber are knots, checks, pitch pockets, shakes, and stains.

Wood cutting techniques

Grading of wood

Sample of Stress Grading of Softwood for Structural Applications

Grade Designation	Design Values, psi				
	Bending	Tension Parallel to Grain	Compression Parallel to Grain	Modulus of Elasticity	Minimum Modulus of Elasticity
900f-1.0E	900	350	1,050	1,000,000	510,000
1650f-1.3E	1,650	1,020	1,700	1,300,000	660,000
1950f-1.5E	1,950	1,375	1,800	1,500,000	760,000
2250f-1.7E	2,250	1,750	1,925	1,700,000	860,000
2400f-2.0E	2,400	1,925	1,975	2,000,000	1,020,000
2850f-2.3E	2,850	2,300	2,150	2,300,000	1,170,000
3000f-2.4E	3,000	2,400	2,200	2,400,000	1,220,000

According to American Forest & Paper Association

Wood cutting techniques

Preservative Treatment

- Petroleum-based solutions are the principal types of wood preservatives.
- The degree of preservation achieved depends on the type of preservative, the degree of penetration, and the amount of the chemical retained within the wood.
- Effective preservatives must be applied under pressure to increase penetration into the wood.
- The advantages of the waterborne preservative over the oil-based are cleanliness and its ability to be painted.
- The disadvantage of some of these treatments is their removal by leaching when exposed to moist conditions over long periods of time

Defects in Lumber

- Lumber may include defects that affect either its appearance, its mechanical properties, or both.

- These defects can have many causes, such as:
  - ✓ natural growth of the wood,
  - ✓ wood diseases, animal parasites,
  - ✓ too rapid seasoning, or
  - ✓ faulty processing
- Common defect types include:
  - ✓ **Knots** – Knots are branch bases that have become incorporated into the wood of the tree trunk or another limb. Knots degrade the mechanical properties of lumber, affecting the tensile and flexural strengths
  - ✓ **Shakes** – are lengthwise separations in the wood occurring between annual rings. They develop prior to cutting the lumber and could be due to heavy winds.

Defects in Lumber

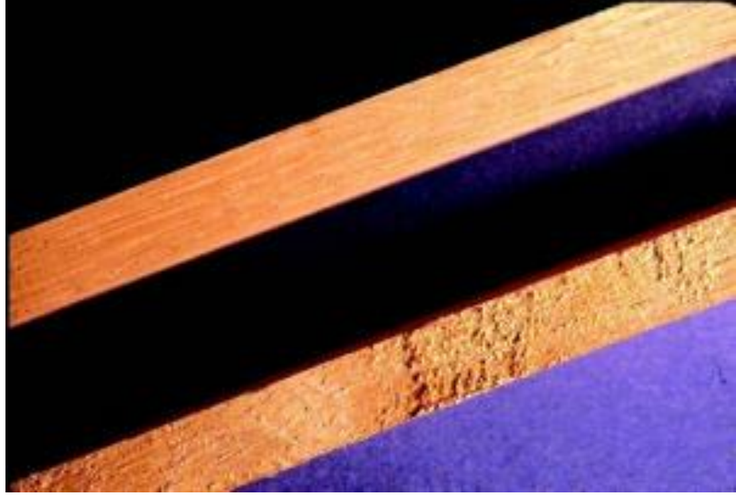
- Common defect types include:
  - ✓ Wane – This is bark or other soft material left on the edge of the board or absence of material.
  - ✓ Sap Streak - is a heavy accumulation of sap in the fibers of the wood, which produces a distinctive streak in color
  - ✓ Reaction Wood - abnormally woody tissue that forms in crooked stems or limbs. It causes the pith to be off center from the neutral axis of the tree. It creates internal stresses which can cause warping and longitudinal cracking.
  - ✓ Pitch Pockets - are well-defined openings between annual rings that contain free resin.
  - ✓ Bark Pockets - are small patches of bark embedded in the wood. These pockets form as a result of an injury to the tree, causing death to a small area of the cambium. The surrounding tree continues to grow, eventually covering the dead area with a new cambium layer.

Defects in Lumber

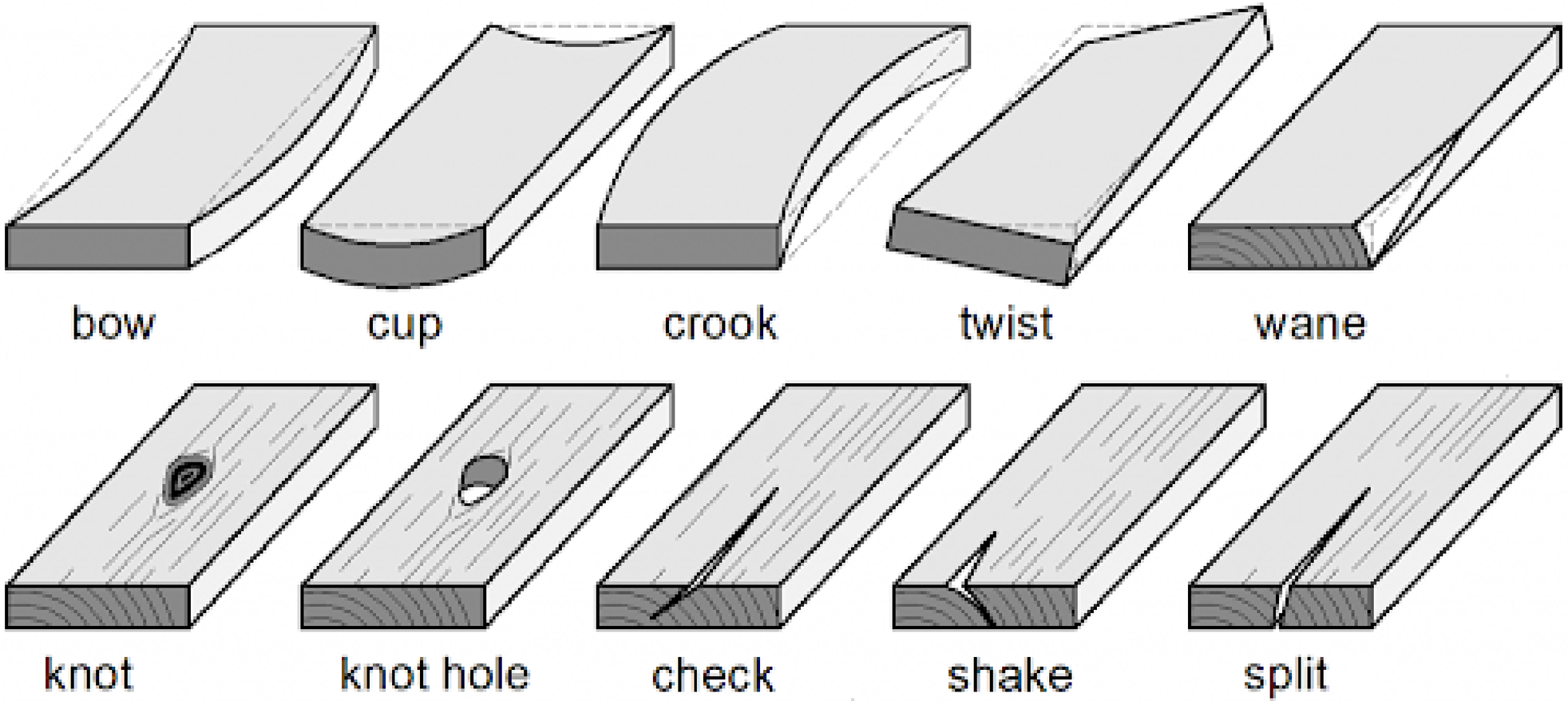
- Checks - ruptures in wood along the grain that develop during seasoning. They can occur on the surface or end of a board. Surface checking results from the differential shrinkage between radial and tangential directions and is confined mostly to planer surfaces. Cracks due to end checking normally follow the grain and result in end splitting.
- Splits - are lengthwise separations of the wood caused by either mishandling or seasoning
- Warp - is a distortion of wood from the desired true plane. The four major types of warp are bow, crook, cup, and twist. Bow is a longitudinal curvature from end to end. Crook is the longitudinal curvature side to side. Both of these defects result from differential longitudinal shrinkage. Cup is the rolling of both edges up or down. Twist is the lifting of one corner out of the plane of the other three. Warp results from differential shrinkage, differential drying due to the production environment, or from the release of internal tree stress.

Defects in Lumber

- Raised, Loosened, or Fuzzy Grain - may occur during cutting and dressing of lumber.
- Chipped or Torn Grain - occurs when pieces of wood are scooped out of the board surface or chipped away by the action of the cutting and planing tools.
- Machine Burn – This is when an area that has been darkened by overheating during cutting.



Defects in Lumber



Physical and Mechanical Properties

- Important physical properties include:
  - ✓ specific gravity and density,
  - ✓ thermal properties, and
  - ✓ electrical properties
- Typical mechanical properties of interest to civil and construction engineers include:
  - ✓ modulus of elasticity - stress–strain relation of wood
  - ✓ strength properties - modulus of rupture in bending, compressive strength parallel and perpendicular to the grain, tensile strength parallel to the grain, and shear strength parallel to the grain.
  - ✓ creep – permanent sag in a wood member
  - ✓ damping capacity – measure of amplitude of vibration in a material

Thank You!!!