3.0 Structural strength and stability depend on the properties of different materials and how they are joined

3.1 Materials and Their Properties

Classifying Material Properties

Materials - the properties or characteristics of different materials must match the purpose of the structure. Properties Include: Brittleness, Ductility, Hardness, Plasticity,, Resistance to heat, Resistance to water, Compression, Tensile strength.

Kinds of Materials:

- Composite Materials
  There are different kinds of strength
  - tension (pulling) …. steel rods
  - compression (pushing) …. concrete
  To enable the structure to withstand both types of forces acting on it, a composite material is used - reinforced concrete (concrete poured over steel rebar (rods).
- Layered Materials
  Layers of different materials (Tetra Pak) are pressed and glued together, combining the properties of the different materials. The layers are often called laminations.
- Woven or Knit Materials
  Spinning or twisting, looping or knotting fibres together gives material added strength. A loom is used to weave two or more pieces of yarn together in a criss-cross pattern to make cloth. Pressing, gluing, melting and dissolving are also ways to combine materials to gain strength.

Choosing materials involves weighing advantages and disadvantages of the different materials
Factors to consider:

- Aesthetics
- Cost
  - will inexpensive material you use allow the structure to perform its function over a reasonable time?
- Appearance
  - is the appeal of the structure 'pleasing' over time?
- Environmental Impact
  - does the structure harm the environment?
- Energy Efficiency
  - does the structure conserve energy?
- Consumer demand and availability
- Disposal of waste

Testing Deformation and Flexibility of Materials in Structures

Deformation is a change in the shape ina structure or any structural component, because the material is unable to resist the load acting on it. When too much deformation occurs within a structure, the structure will fail.

Flexibility is the ability of a material to be bent under force without breaking. How much an object can change shape without breaking under a given load is a measure of its flexibility.

3.2 Joining Structural Components

The place at which structural components in a structure are joined together is called a **joint.** Ties, like thread, string and rope, fasten things together.

Joints that Rely on Friction

Friction is the force that results when the surface of one object moves against the surface of another object. The strength of the force of friction also depends on the roughness or smoothness of the surfaces in contact with each other.

- Fasteners (nails, staples, bolts, screws, rivets and dowels). Unfortunately, the holes made in the structure, by the fastener, actually weaken the structure. One fastener allows movement when the parts are pushed or pulled, whereas, more than one will make a more rigid joint - but, will also weaken it more.
- Interlocking shapes (like Lego) fit together because of their shape. Dovetail joints in drawers, dental fillings and folded seams are some examples.
- Mass - The friction between the base of the block and the surface underneath is enough to keep the block from moving

Joints that Rely on Bonding

- Adhesives, or sticky substances can also hold things together. Thermosetting glues (hot glue) and solvent-based glues (drying glue) strengthen the joint because of the bonds between the particles (like epoxy resins). Even the strongest adhesives can fail under extreme conditions and if the joint is stronger than the material it is joining, the material next to the joint can fail. Adhesives can also be a health hazard (like Super Glue - which dries very quickly when you use it - possibly bonding your skin if you touch it, or they can release harmful chemical vapours as they harden.
- Melting - Pieces of metal or plastic can be melted together (welding, soldering - brazing or using chemicals)

Post-It Notes - An accidental glue (that turned into a huge success story). It did not meet the specifications, because it couldn't hold things together very well.

Fixed or Movable? Which Joint For Which Structure?

Rigid, or Fixed Joints do not allow movement and usually result from bonding type joints. Mobile, or Flexible Joints are joints that allow movement.

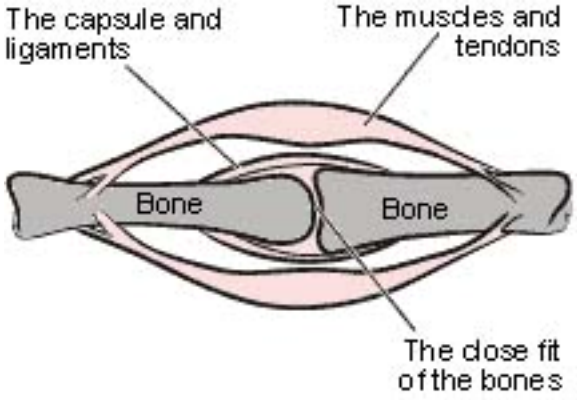
Designing Joints To Last

If a structure is to last a reasonable time, it must be designed to withstand the forces acting on it over time. Extremes in weather, repeated movement, and other exceptional forces can affect the life expectancy of a structure.

3.3 Properties of Materials in Plant and Animal Structures

Materials in Animal Structure

Bones, Ligaments, and Cartilage
Bones are hard and rigid, forming a structural frame. The bones are connected with ligaments, which are strong, flexible connective tissue. Cartilage, found at the end of some bones, reduces friction and provides a smooth surface for movement.

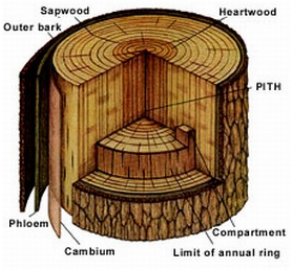


Muscles and Tendons
The muscles allow the skeletal frame to move. The fibrous muscle tissue is connected to bones like tendons, contracting and relaxing, allowing the bones to be pushed and pulled.

Joints
The joints in the body are specialized for various functions. Ball and socket joints in the shoulders and hips permit movement in many directions. Elbow and knees are hinge joints and allow movement forward and back. Joints that do not allow any movement, like the skull, ensure that the organ it covers will be protected

Skin, The Human Shell
The skin, a tough, flexible material, provides the structural shelter for all other parts of the human body. It waterproofs and protects it from harmful bacteria. It also helps to keep the body temperature constant, allowing it to perspire and shiver.

Materials in a Tree's Structure



The **outer bark** is the tree's protection from the outside world. It insulates against cold and heat and wards off insect enemies. The **inner bark,** or "phloem", is pipeline through which food is passed to the rest of the tree. The **cambium cell layer** is the growing part of the trunk. It produces new bark each year and new wood in response to hormones that pass down through the phloem with food from the leaves. **Sapwood** is the tree's pipeline for water moving up to the leaves. Sapwood is new wood. **Heartwood** is the central, supporting pillar of the tree. Although dead, it will not decay or lose strength.