Lec. 2 **Dr. Sahar**

Dental Materials

Mechanical Properties of dental materials

One of the most important properties of dental material is the ability to withstand the various mechanical forces placed on them during their use as restoration, appliances & tools.

1.Strength: is the measure of the resistance of the material to the externally applied forces.

Types of strength:

1. Transverse Strength:

It is the strength of the middle of a beam which is supported only at its ends, it is important in dental bridges.



2. Fatigue Strength:

Occurs when the material constantly subjected to change in shape due to frequent application of force like clasp arm of partial denture.



3. **Impact Strength:**

It is the ability of the material to break on sudden impact, like dropping of the denture.



2.Stress: is the force per unit area induced in a body in response to some externally applied force. The unit of stress is the unit of force {Newton (N)} divided by a unit of area, and is commonly expressed as Pascal (1 Pa = 1 N/m2 = 1 MN/mm2).

$$\text{Stress } (\sigma) = \frac{\text{Force}}{\text{Unit area}}$$

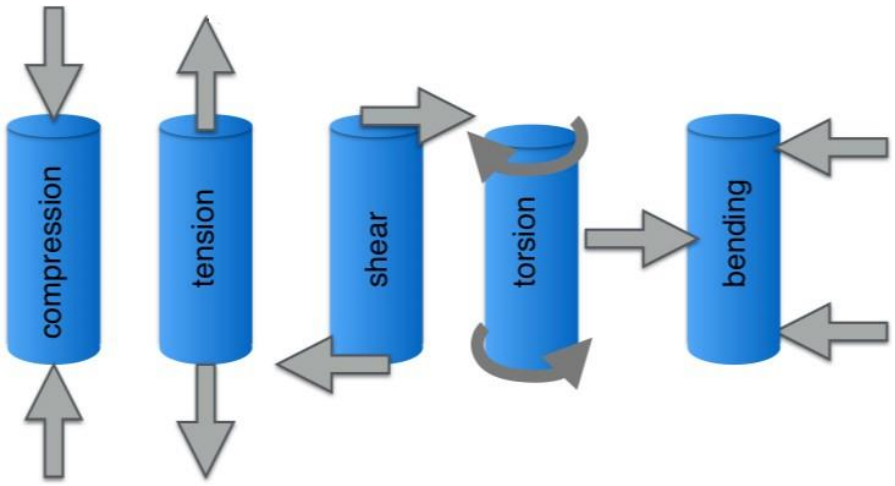
There are different types of stresses according to the direction of the applied force:

A- Tensile stress:

It results from two sets of forces directed away from each other in the same straight line or when one end is fixed and the other end is subjected to a force directed away from the fixed end (force which tends to stretch or elongate the material). This stress is accompanied by tensile strain.

B- Compressive stress:

It results from two sets of forces directed toward each other in the same straight line or when one surface is fixed and the other is subjected to a force directed toward the fixed end (force that compress or shorten the material). lt is accompanied by compressive strain. Investment material and restorative materials should have high compressive strength.



C- Shear stress:

Is the result of two sets of forces directed parallel to each other (not along the same straight line) which is applied to one part of the body in one direction while

the other is in the opposite direction. The result is sliding of the molecules over each other (tearing). It is accompanied by shear strain.

Usually three types of stress occur at the same time, if a piece of metal is being bend it will exhibit tensile stress on the outer surface, compressive on the inner & shear in the middle.

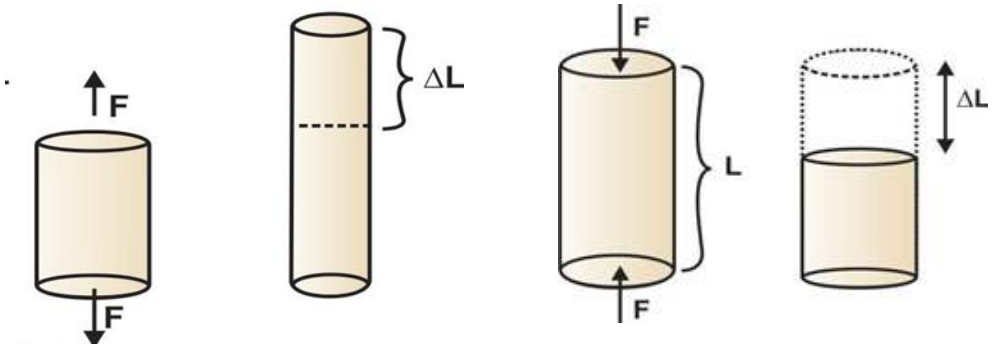
D- Flexural stress (bending stress): It results from an applied bending force.

E-Torsion stress: Force per unit area of a material that is subjected to twisting.

3.Strain (Ɛ): is the change or deformation in length (dimension) per unit length (dimension) caused by external force. It has no unit of measurement.

$$\text{Strain} = \frac{\text{Change in length } (\Delta L)}{\text{Original length } (Lo)} = \frac{L - Lo}{Lo} = \frac{\Delta L}{Lo}$$

Strain under tensile stress is an **elongation** in the direction of loading.
Strain under compression is **shortening** of the body in the direction of loading.



Elongation Shortening

Types of the strain

1. Temporary or recoverable strain: the material is returned to its original form after removal of the applied force.

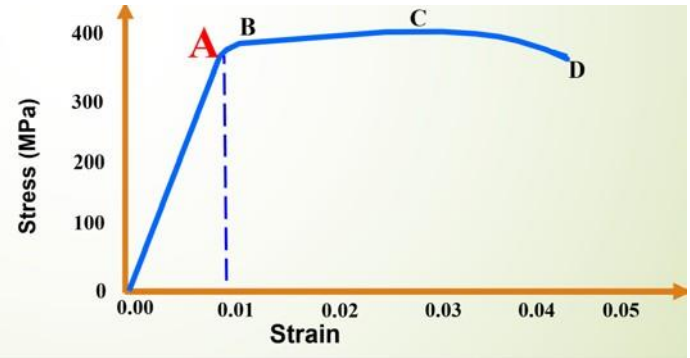
2. Permanent or unrecoverable strain: the material is not returned to its original length after removal of the applied force.

Stress- Strain Curve (S-S curve):

Is a plot represent the relationship between stress and strain is that is used to study the mechanical properties of dental materials. The stress is plotted vertically, and the strain is plotted horizontally. As the stress is increased the strain is increased.

Elastic deformation (elastic or proportional limit) (A point): The greatest stress to which the material can be subjected and will return to its original shape & dimension without permanent deformation the stress is removed.

Plastic deformation: Occures when the stress is increase beyond the elastic or the proportional limit and the material will deform and will not return to its dimension if we remove the stress.



*The region of the s-s curve before the proportional limit is called the **"elastic region"** (from 0 to A).

*The region of the curve beyond this proportional limit is called as **"plastic region"** (from A to D).

Ultimate strength (C point): It is the maximum stress that a material can withstand before failure.

Fracture strength (D point): The stress at which a material fracture.

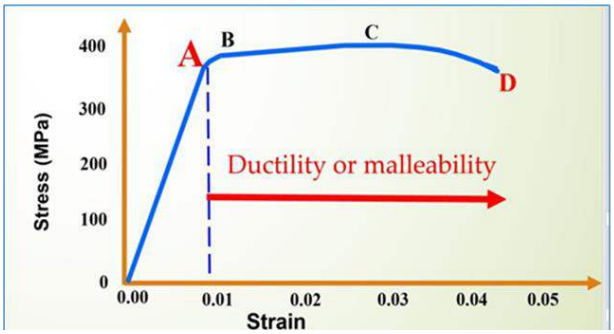
Flexibility: The higher strain which occurs when the material is stressed to its

proportional limit.

Malleability: It is the ability of the material to withstand permanent deformation under compressive stress without fracture. It's the ability of the material to be drawn into sheet like gold.

Ductility: It is the ability of the material to withstand permanent deformation under tensile stress without fracture. It's the ability of the material to be drawn into a fine wire (gold: most ductile).



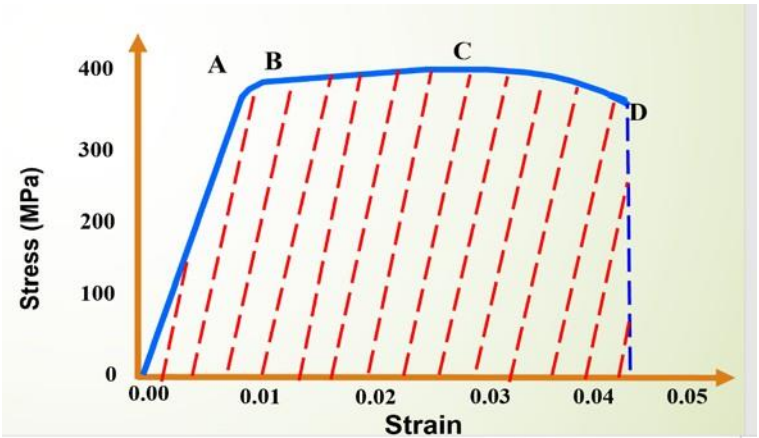


Brittleness: It is the opposite of ductility and malleability.

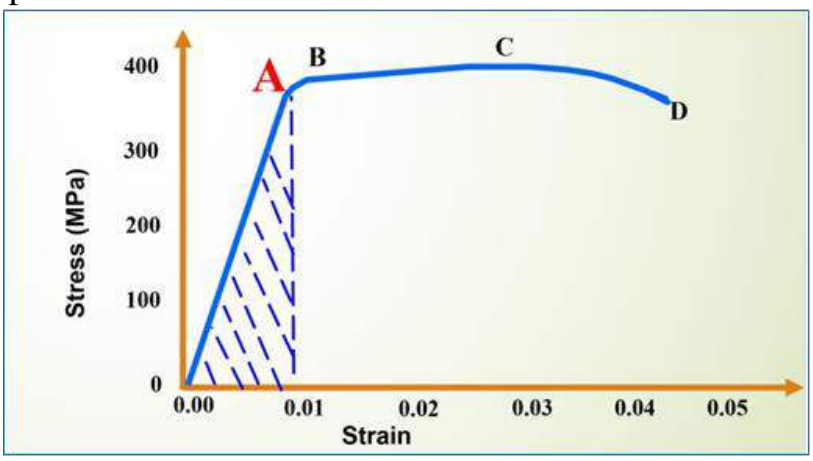
**Elastic strain = flexibility.

** Plastic strain = ductility or malleability

Toughness: It is the total work or energy required to break the material. (It's the total area under the stress – strain curve.

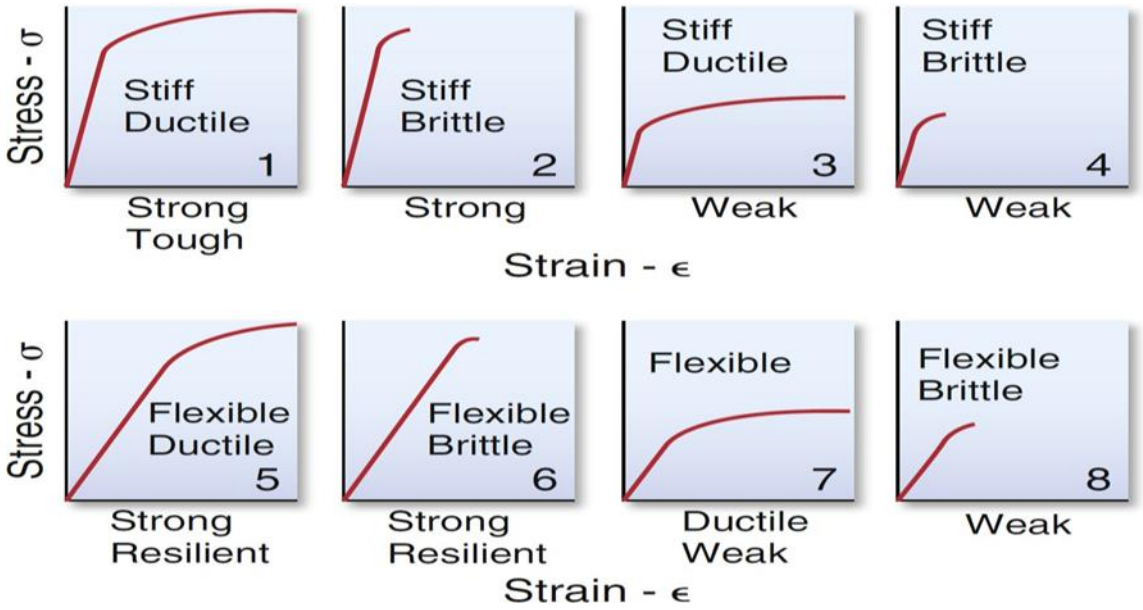


Resilience: The amount of energy absorbed by a structure when it is stressed within the proportional limit. Or it is the energy needed to deform the material to its proportional limit.



Properties of Stress-Strain Curves

The shape of a stress-strain curve and the magnitude of stress and strain allow the classification of materials as regard to their properties e.g. weak, strong, flexible, stiff, ductile, brittle, resilient and tough.



Hardness: It is the resistance of the material to deformation caused by penetrating or scratching the surface. It is done either by using steal ball (Brinell or Rocwell test) or using diamond (Vickers and Knoop test). The higher the number, the harder the material.

