General properties

Dental materials: It is the science which deals with the materials used in dentistry, their physical, chemical and mechanical properties and with their manipulation.

The American dental association **(A.D.A)** determined the physical and chemical properties of dental materials. The A.D.A primary objective is to formulate standards or specification for all dental materials and it certify the products which meet those requirements. Any new material must be certified by the A.D.A.

The study of dental material enables the dentist to understand the behavior of these materials and how to use them to their best advantages.

General properties of dental materials:

All materials have physical properties like color, weight, solubility, thermal conductivity and others, also mechanical properties like hardness or softness, strength or weakness. There is no material till now which has ideal physical and mechanical properties, most dental materials have some good and bad properties.

Physical properties:

Color:

Many dental restorative materials have to look like natural teeth and should not stain or change its color by time. The anterior filling and artificial tooth material should be translucent, also should look like natural tooth substance at different light conditions, such as day light and artificial light (fluorescent light).

For dentures, the acrylic denture base material should have the same appearance of natural gum.

Linear coefficient of thermal expansion and contraction:

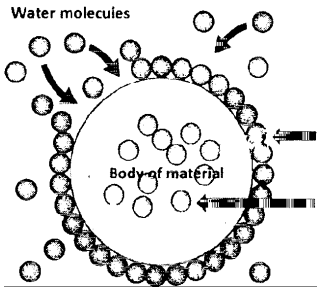
As the temperature rises a solid material will expand and on cooling it will contract, this is measured by the linear coefficient of thermal expansion and contraction which is the change in length per unit length for 1°C temperature change.

Filling materials should have the same coefficient as the tooth, if it does not, it will press too hard against the cavity wall on expansion and may cause pressure on the pulp or pull away from the wall when chilled by cold water.

Dimensional stability:

Amalgam is filling material for posterior teeth it may sometimes change shape permanently as a result of heavy occlusal biting force, this is bad property. The alginate impression material when absorb water it will expand but when alginate loss water it will contract.

Absorption of fluids: Some materials will absorb water or other fluids. If it is too much or continued for long time, this will result in serious dimensional changes and the material would also be unhygienic (cause bacterial colonization). On the other hand, some materials like acrylic will absorb water for a day and stops after that, so it is acceptable.



Density:

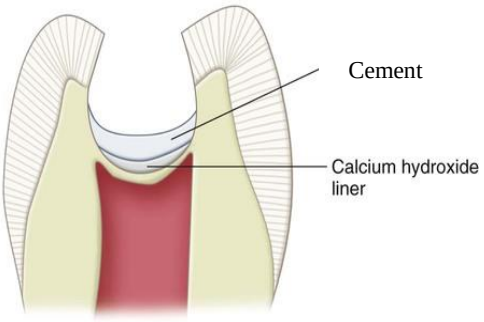
Lightness of the material is nearly always an advantage in restorative materials, but sometimes metal is used inside full lower denture to make it heavy to control its mobility.

Solubility:

Restorative materials like teeth fillings should not dissolve in the mouth, and if it dissolves, it should not release toxic substances.

Tissue reaction:

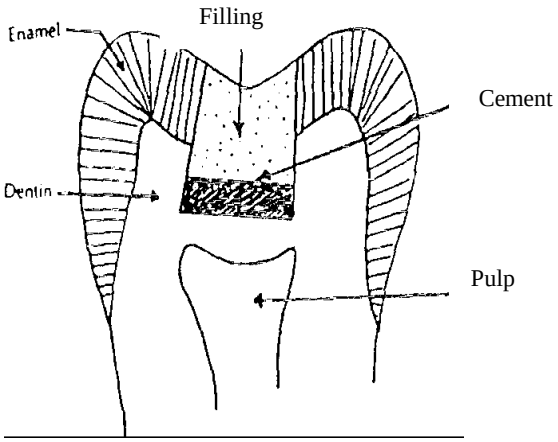
Some restorative materials are damaging to the living tissue which is in contact with it, like zinc-phosphate cement contain phosphoric acid may kill the dental pulp unless a protective lining is used. Also dental material should not show any allergic reaction to the tissue.



Thermal conductivity:

it the amount of heat in calories or joules passing through a body of (1cm thick and 1cm^2 cross section) per seconds when the temperature difference is 1^{o}C.

Generally, metals are better heat conductors than non-metals. Metal filling material like amalgam sometimes cause pulp pain by transmission heat or cold more than natural tooth especially in deep cavities. Thus they require heat insulating layer between the filling and the pulp. On the other hand the thermal conductivity of metallic denture base material is an advantage as it gives feeling closer to the normal condition and the patient will feel normal also it will protect him from drinking very hot drinks which may burn his mouth.



Adhesion and cohesion:

Adhesion: is the attraction force between the molecules of different substances (materials) like adhesion force between denture base and underlining tissue.

Cohesion: is the attraction force between the molecules of the same substance (materials) like the cohesion between the molecules of the denture base to each other.

Mechanical properties:

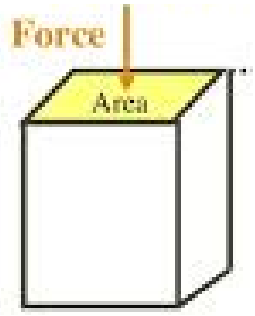
One of the most important properties of dental material is the ability to withstand the various mechanical forces applied on it during their use inside patient mouth.

Force:

The force is generated by one body interacting with another. The applied force to an object cause either translation of the object (movement) or deformation of the object (change its shape). The force is defined by three factors:

1) Point of application.
2) Magnitude.
3) Direction of force.

Inside patient mouth there is occlusal force, we must put the surface area in mind when talking about the force because this force applied to a specific surface area so we have to deal with stress.



Stress: The force per unit area area.

$$\text{Stress} = \frac{\text{Force (N)}}{\text{Area (Cm}^2\text{)}}$$

When force applied to constant body, resistant developed opposite to this external force, this internal reaction (force) equal in intensity and opposite in direction to the external applied force.

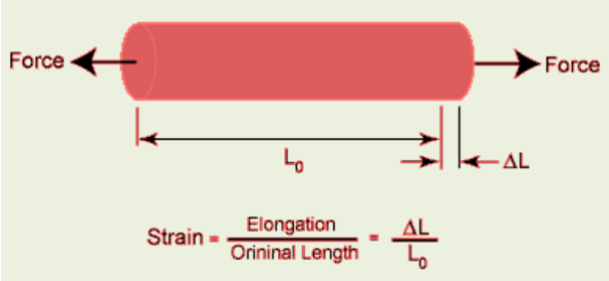
Strength:

It is the internal reaction opposite to the externally applied force.

Strain:

It is the deformation of the deformable body when the force applied on it. It is the change in length per original length.

Strain = (final length - original length) / original length.

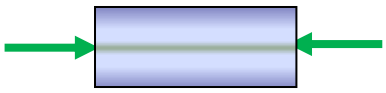


- When occlusal stress applied on dental restoration it result in strain on this restoration.

Types of stress:

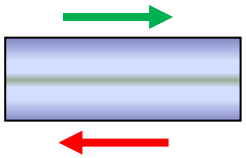
1-Tensile stress: Two sets of forces applied on the body away from each other in one line. it is accompanied by tensile strain.

2-Compressive stress: Two sets of forces applied on the body toward each other in one line. lt is accompanied by compressive strain.



3-Shear stress: Two sets of forces applied on the body toward each other in different lines Shear force is the force which cause tearing a paper or a card.

It is accompanied by shear strain.

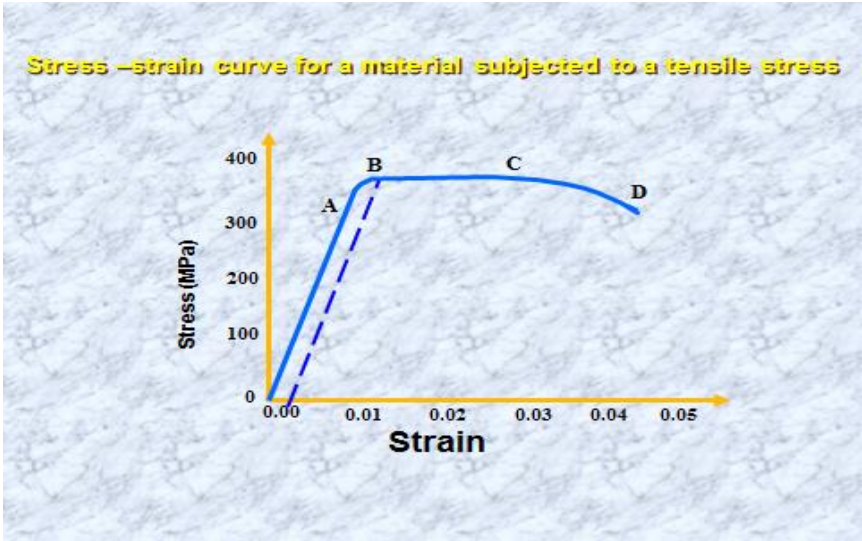


Elongation:

The deformation (strain) result from application of tensile stress.

STRESS -STRAIN CURVE

When a stress is applied to a material, the material will extend to in an amount proportional to the magnitude of applied stress.



Proportional limit:

The greatest stress the martial withstand without deviation from the linear proportion of stress to strain, and the material will return to its original shape and dimension when the stress is removed (Point A on picture).

If the stress is increased beyond the elastic limit (proportional limit) the material will deform and if we remove the stress the material will not return to its dimension.

If the stress is increased more and more, the material will fracture.

Ultimate strength:

It is the maximum stresses the material withstand before failure in tension (Point C on picture).

Fracture strength:

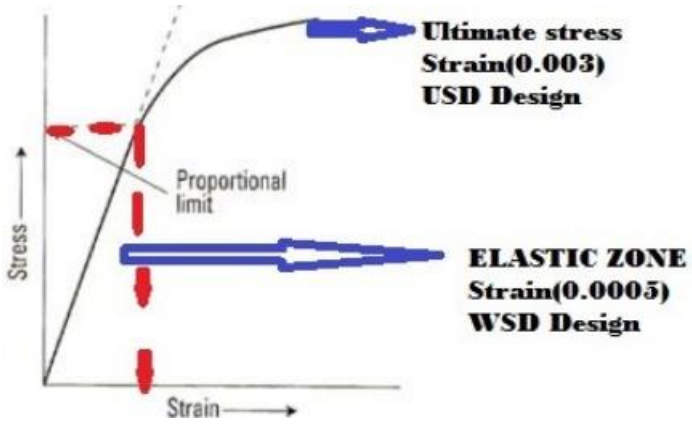
The stress at which the material fracture (Point D on picture).

Modulus of elasticity:

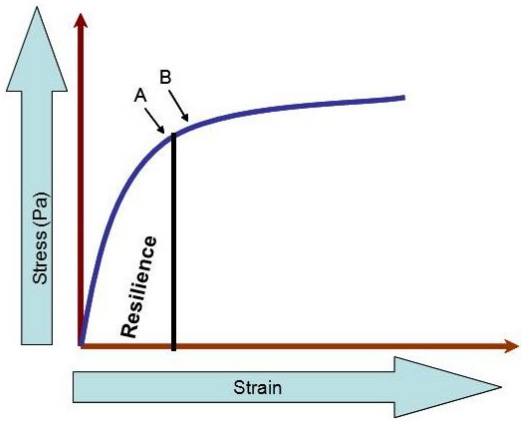
It is the stress with in the proportional limit divided by the strain (Ratio).

$$\text{Modulus of elasticity} = \frac{\text{Stress within proportional limit}}{\text{Strain}}$$

From modulus of elasticity we can distinguish stiff material from flexible material. If the modulus of elasticity high the material more stiff and if the modulus of elasticity low the material more flexible.

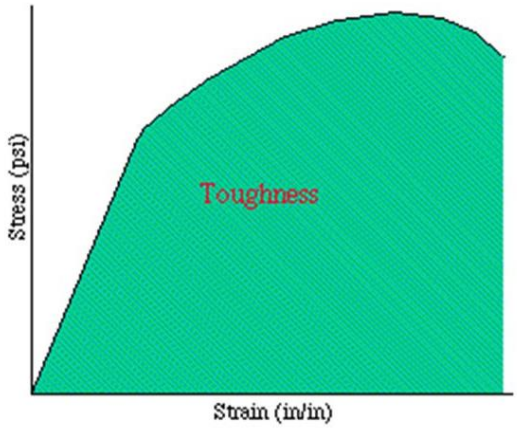


Resiliency: The amount of energy absorbed by a structure when it is stressed within the proportional limit. It is the resistant of the material to permanent deformation (The area under the stress-strain curve within proportional limit).



Toughness:

It is the amount of energy required to cause fracture of the material. It is the resistant of the material to fracture (The total area under the stress-strain curve).



Fatigue strength:

It is the stress (within proportional limit) at which the material fail under repeated loading. Like clasp arm of partial denture.

Impact strength:

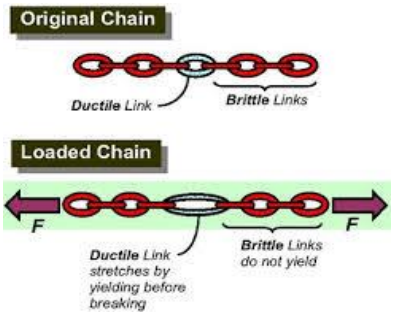
It is the ability of the material to break on sudden impact. Low impact strength means brittle material, like when the complete denture dropping it will fracture.

Malleability:

It is the ability of the material to be hammered in to a sheet without fracture. Permanent deformation occurred to the material under compressive stress without fracture.

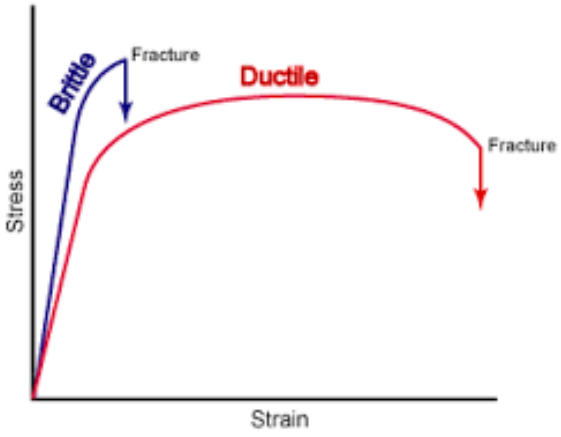
Ductility:

It is the ability of the material to be drawn in to a wire in tension.



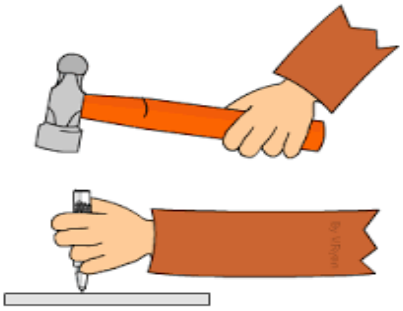
Brittleness:

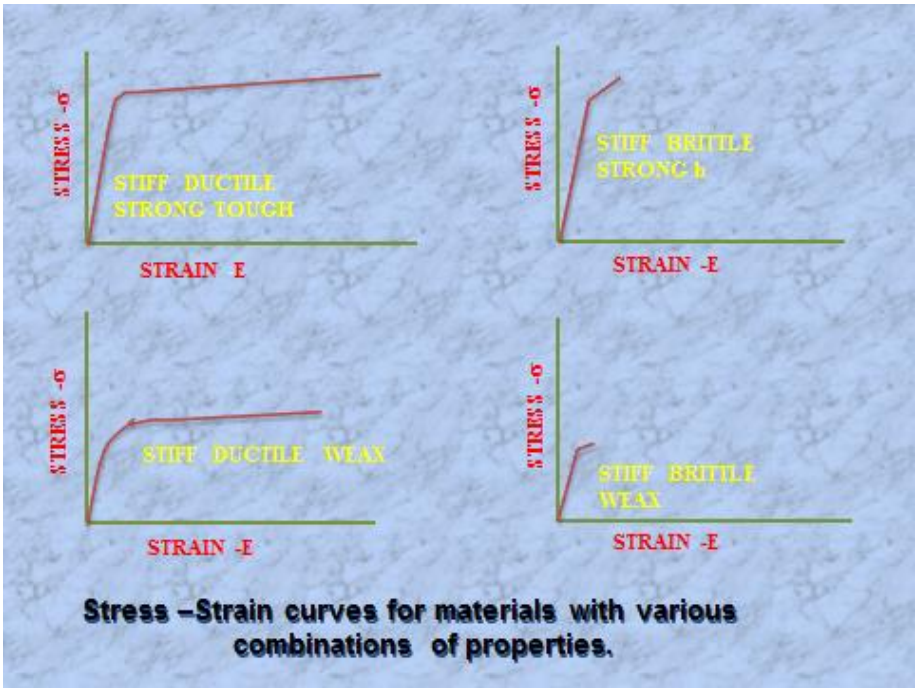
It is the opposite of ductility; brittle material lack of plasticity and it fracture when stressed above the proportional limit, like glass.

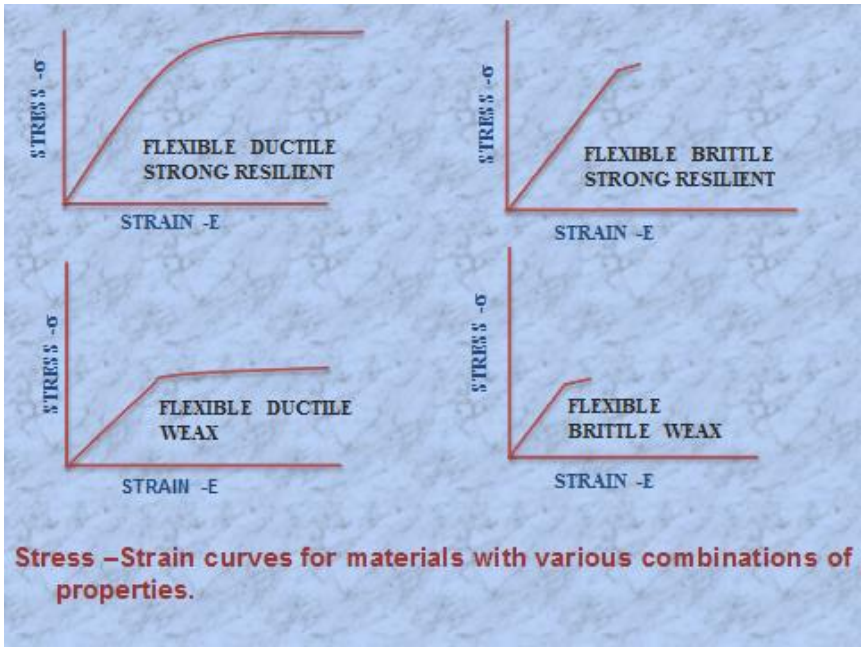


Hardness:

It is the resistance of the material to surface penetrating or scratching.







Stress –Strain curves for materials with various combinations of properties.