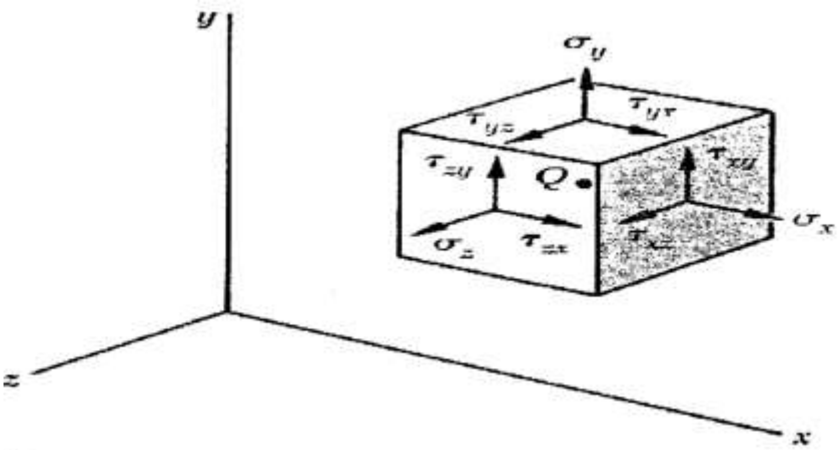
General Definition

Homogeneous Material: A material which has a uniform structure throughout without any discontinues, such as metals, alloys and ceramic.

Non-Homogeneous Material: A material which has a structure that varies from point to point dependence on its constituent and the presence of impurities, such as concrete.

Isotropic Material: A material which exhibit uniform properties in all directions; physical and mechanical properties are equal in all orientations or directions.



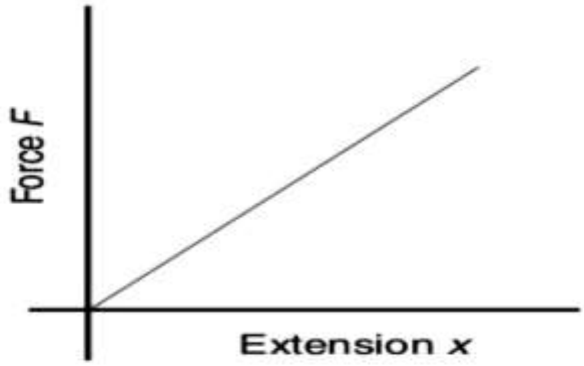
Non-Isotropic (Anisotropic) Material: A material which not exhibit uniform properties in all directions.

Orthotropic Material: A material which has different properties in different planes, such as wood.

Elasticity and Plasticity

Elasticity: Is the ability of a material to return to its original shape and size on the removal of external forces.

Plasticity: Is the property of a material of being permanently deformed by a force without breaking. Thus, if a material does not return to the original shape, it is said to be plastic. Within certain load limits, mild steel, copper, polythene and rubber are examples of elastic materials; lead and plasticine are examples of plastic materials. If a tensile force applied to a uniform bar of mild steel is gradually increased and the corresponding extension of the bar is measured, then provided the applied force is not too large, a graph depicting these results is likely to be as shown in below Figure. Since the graph is a straight line, extension is directly proportional to the applied force.

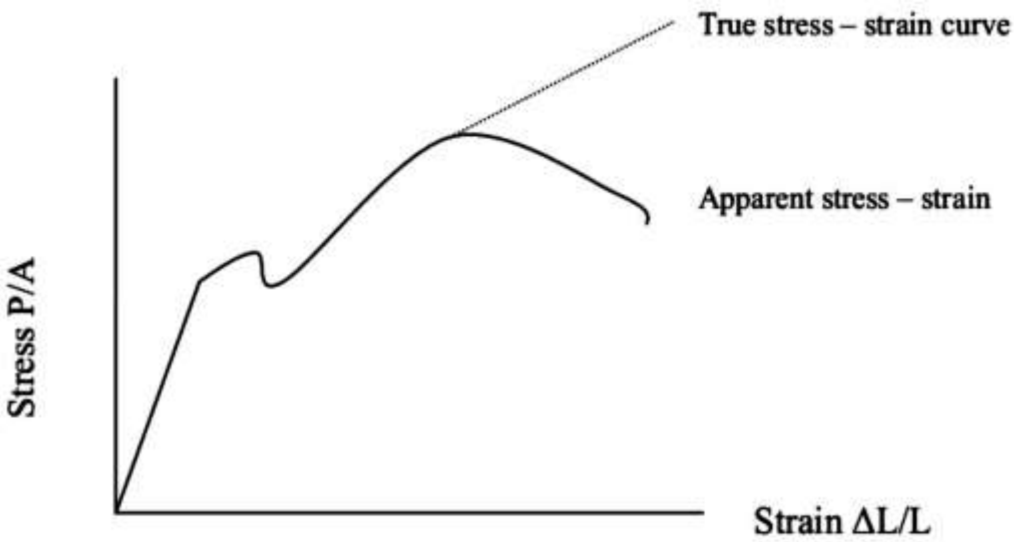


The point on the graph where the extension is no longer proportional to the applied force is known as the limit of proportionality. Just beyond this point the material can behave in a non-linear elastic manner, until the elastic limit is reached. If the applied force is large, it is found that the material becomes plastic and no longer returns to its original length when the force is removed. The material is then said to have passed its elastic limit and the resulting graph force/extension is no longer a straight line.

Ductility, brittleness and malleability

Ductility: Is the ability of a material to be plastically deformed by elongation, without fracture. This is a property that enables a material to be drawn out into wires. For ductile materials such as mild steel, copper and gold, large extensions can result before fracture occurs with increasing tensile force. Ductile materials usually have a percentage elongation value of about 15% or more.

Brittleness: Is the opposite of toughness and ductility and refers to small resistance to sudden blow. A brittle material breaks suddenly without significant permanent deformation or warning of approaching failure.



Stress- strain curve for a ductile material

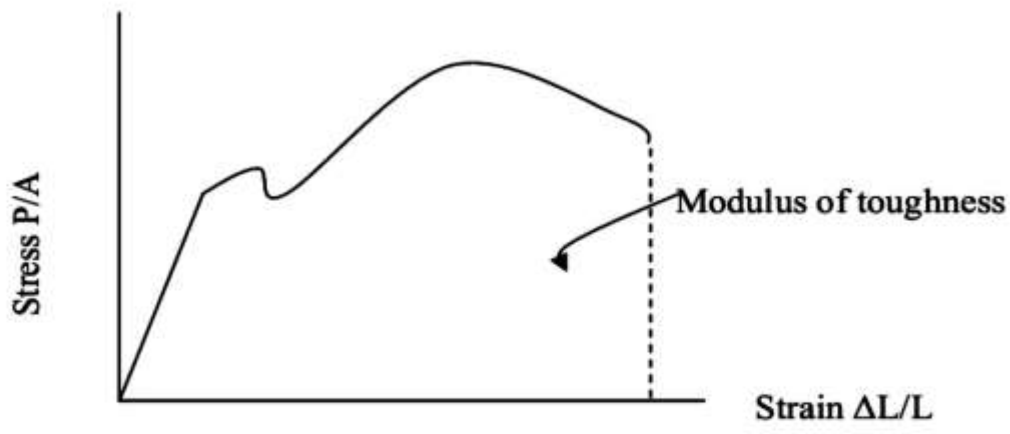
Stress – Strain curve for non ductile material – Cast iron (no plastic deformation)

Malleability: Is the property of a material whereby it can be shaped by hammering or rolling. A malleable material is capable of undergoing plastic deformation without fracture. Examples of malleable materials include lead, gold, putty and mild steel.

Toughness and stiffness

Toughness: A resistance to impact and represent the ability of material to support load even after yielding or crack formation. Toughness enable material to endure shock or blows, or toughness is also considered to mean resistance to fracture when material is deformed above the elastic limit, an increment in toughness lead to increase in the amount of energy needed to produce damage. The area under stress – strain curve represents the **modulus of toughness**.

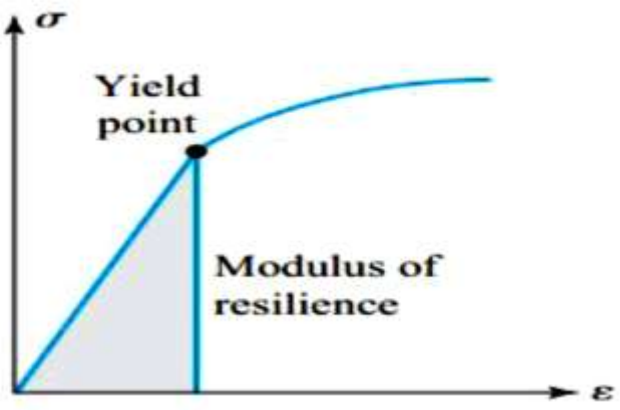
Toughness is measured in units of joules per cubic meter (J/m3).



Stiffness: The mechanical property that defines the resistance in the elastic range is called stiffness, and is measured by value known as 'Modulus of Elasticity', which is determined from the slope of the initial straight line portion of the tensile curve.

Hardness: Is resistance to plastic deformation. Thus a hard material may have a high elastic limit. Other meanings are given to term, however, such as resistance (1) to abrasion, (2) to scratching, or (3) to indentation of a cone or ball.

Resilience: Is that property of an elastic body by which energy can be stored up in the body by loads applied to it and given up in recovering its original shape when the loads are removed. The area under the straight portion of stress - strain curve represent the modulus of resilience.



Creep:

We have discussed the mechanical properties of materials on room temperature. Many structures, particularly these associated with energy conversion, like turbines, reactors, steam and chemical plant operate at much higher temperature. As the temperature is raised, materials under loads continuous deformation with time, i.e. start to creep, the strain instead of depending only on the stress, now depends on temperature and time also.

$\epsilon = f$ (σ, temp., time)

The temperature at which materials start to creep depends on their melting point. As a general rule, it is found that creep starts when:

T > 0.3-0.4 Tm for metals

T > 0.4-0.5 Tm for ceramic

Where:

T: Temperature at which material start to creep

Tm: The melting temperature in Kelvin