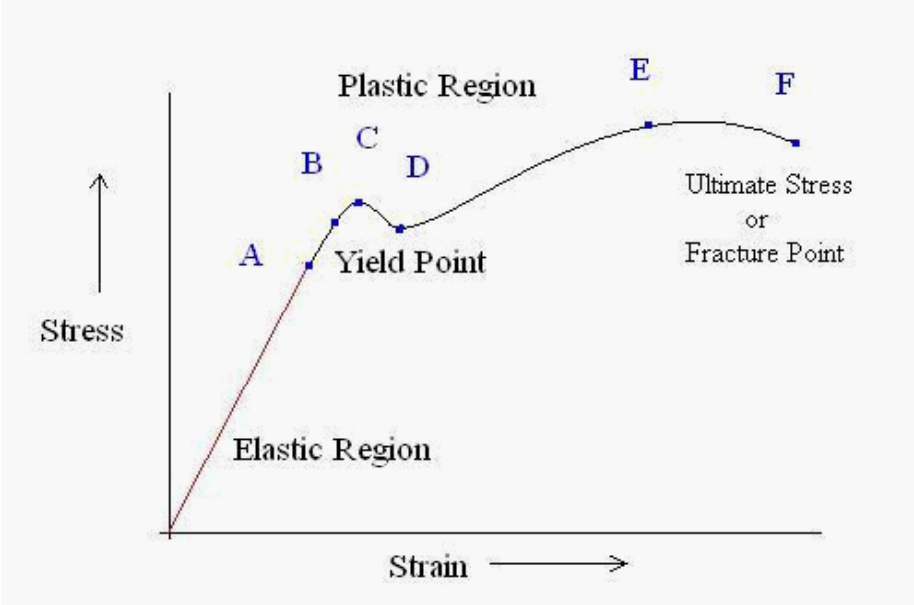
Stress-Strain Diagrams

Stress-Strain Curves for Ductile Materials

If a ductile bar of uniform cross-sectional area is subjected to gradually increasing axial tensile force (generally is done in Universal Testing Machine) till failure of the bar occurs, when the stress-strain curve plots the curve may be divided into following parts:



Stress-Strain curve in ductile materials

Portion *OA*: This portion is absolutely straight, where the stress is proportional to strain and the material obeys Hooke's law ***(σ =E ϵ).*** The value of stress at point A is called proportional limit.

Portion *AB*: In this portion, Hook's law is not obeyed, although the material may still be elastic. The point B indicates the elastic limit.

Portion *BC*: In this portion, the metal shows a strain even without increase in stress and the strain is not fully return when load is removed.

Portion *CD*: Yielding start in this portion and there is a drop of stress at the point D directly after yielding begins at C. The point D is termed as lower yield point and C is called upper yield point.

Portion *DE*: After yielding has taken place at *D*, further straining takes place at this portion by increasing the stress and the stress–strain curve continues to rise up to the point *E*. Strain in this portion is about 100 times that of portion *O-A*. At the point *E*,

the bar begins to form a local neck. The point *E* is termed as ultimate tensile stress point.

Portion *EF*: In this portion, the load is falling off from the maximum and fracture at F takes place. The point F is termed as fracture or breaking point and the identical stress is called breaking stress.

2-Stress Strain Curves for Brittle Materials

Materials which show very small elongation before they fracture are called brittle materials. The shape of curve for high carbon steel, concrete and high strength light alloys or any brittle materials is shown in fig. 3. For most brittle materials the permanent elongation (*i.e.* increase in length) is less than 10%.

Principal mechanical properties

*The characteristics of the materials which describe their behaviour under external loads are known as **Mechanical Properties**.*

Some mechanical properties are:

1 -Elasticity

Elasticity of a material is power of coming back to original position when the stress or load is removed. The greatest stress that a material can withstand without permanent distortion is called elastic limit.

2- Plasticity

The plasticity of a material is ability to undergo some permanent deformation without failure. Plastic deformation will take place only after the elastic range has been exceeded, beyond (point c). Plasticity is an important property and widely used in several mechanical processes like forming, shaping, extruding and many other hot and cold working processes. In general, plasticity increases with increasing temperature.

Due to this property various metals can be transformed into different products of required shape and size. This conversion into desired shape and size is effected either by the application of pressure or heat or both.

3- Ductility

Ductility of a material their enables to draw out into thin wire with application the load. Ductile material such as mild steel, wires of gold, silver, copper, aluminium, etc. are drawn by extrusion or by pulling through a hole in a die due to the ductile

property. The ductility decreases with increase of temperature. The percent elongation and the reduction in area in tension are often used as empirical measures of ductility.

4-Strength

It is the resistance offered by a material when subjected to external loading, so stronger the material can be withstand with greater the load. Depending upon the type of load applied the strength can be tensile, compressive, shear or torsional strength. The maximum stress that any material will withstand before destruction is called its ultimate strength (point E as shown in Fig. 1).

5- Brittleness

The brittleness of a material is the property of breaking without much permanent distortion. There are many materials, which break or fail before much deformation take place, such as glass, cast iron, etc. Therefore, a non-ductile material is said to be a brittle material. A brittle material should not be considered as lacking in strength, it is only shows the lack of elasticity. On stress-strain diagram, these materials don't have yield point and value of E is small.

6- Toughness

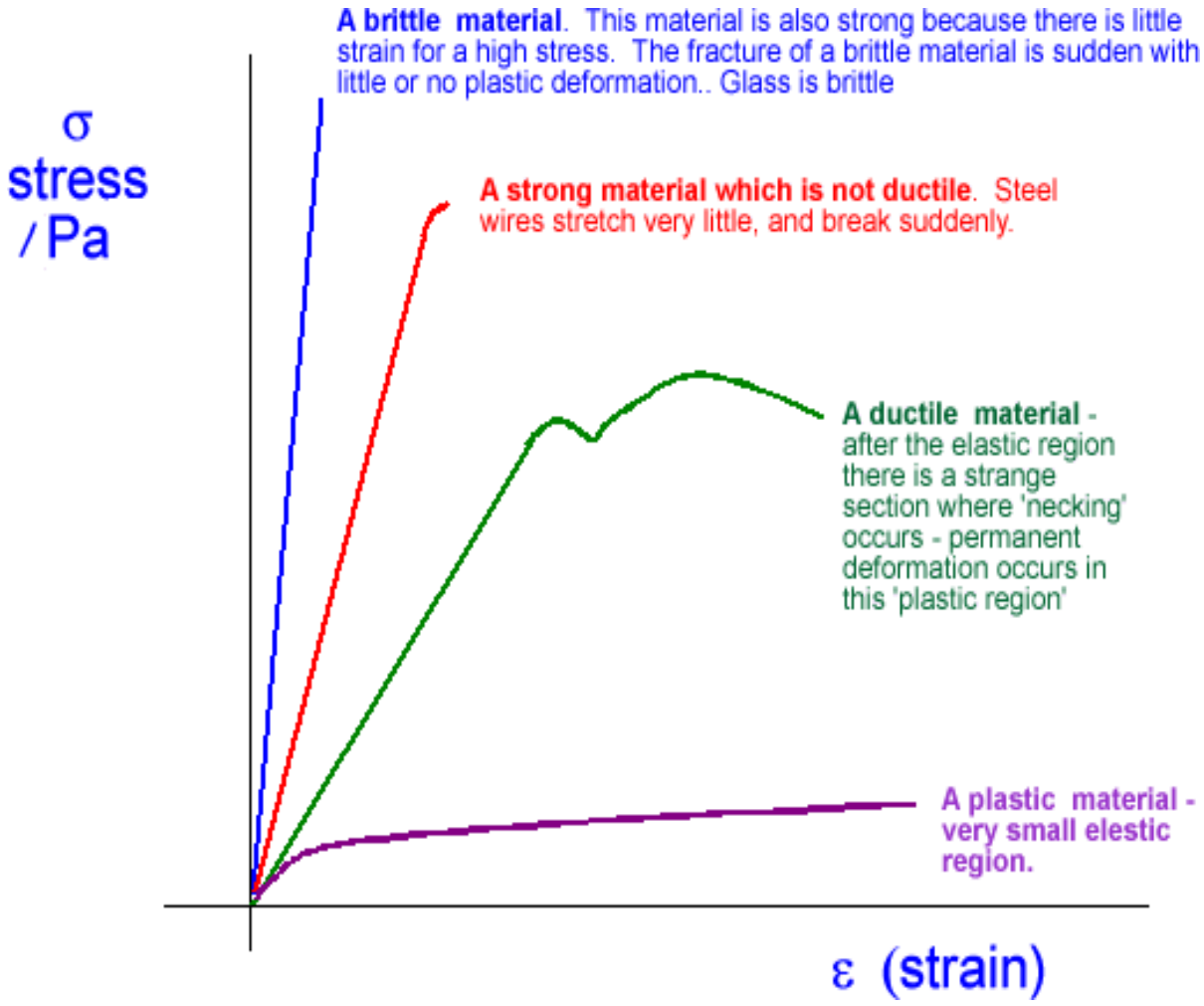
The toughness of a material is ability to withstand both plastic and elastic deformations. It is a highly desirable quality for structural and machine parts to withstand to shock and vibration. Manganese steel, mild steels are tough materials. For Ex: If a load is suddenly applied to a piece of mild steel and then to a piece of glass the mild steel will absorb much more energy before failure occurs. Thus, mild steel is said to be much tougher than a glass.

7- Hardness

Hardness is closely related to strength. It is the ability of a material to resist scratching, abrasion, penetration with apply external load.

8- Stiffness (Rigidity)

The resistance of a material to deflection is called stiffness or rigidity. Steel is stiffer or more rigid than aluminium. Stiffness is measured by Young's modulus *E*. The higher value of the Young's modulus this mean stiffer the material. *E* is the ratio of stress over strain and is given by the slope of line *O–A*.



materials behaviour in stress strain curve