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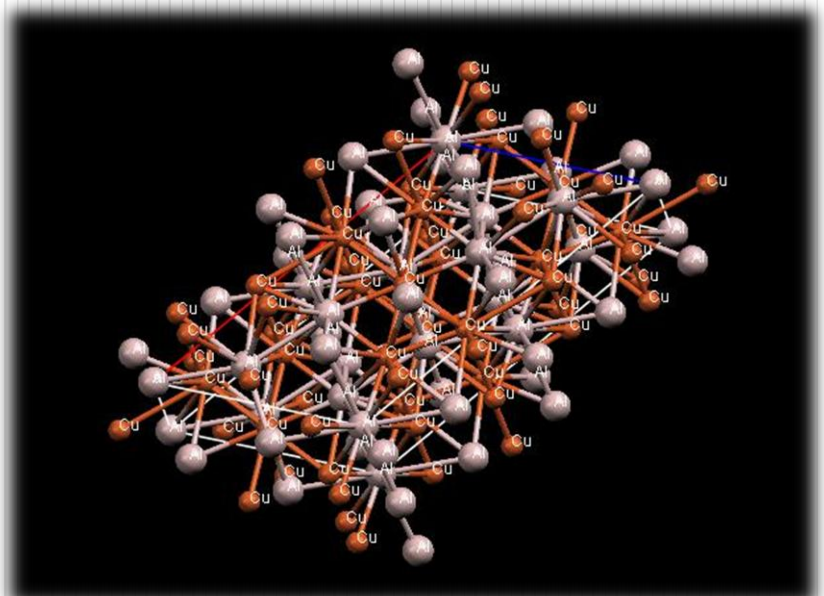
Workshop Practice
TA 102
Lec – 2 & 3 :Engineering Materials



By Prof.A.Chandrashekhar

Engineering Materials

- Materials play an important role in the construction and manufacturing of equipment/tools. Right selection of materials add to the economy, working and life of machinery.
- Materials are building blocks of technology.
- Knowledge of the property and behavioral characteristics of the material is important.

Materials are classified in to 5 major classes :-

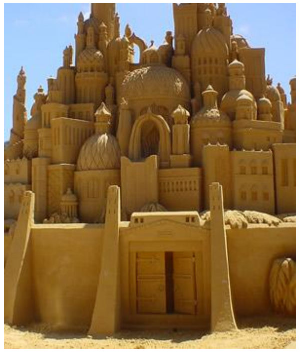
1. METALS
2. CERAMICS
3. POLYMERS
4. COMPOSITES
5. SEMI CONDUCTORS

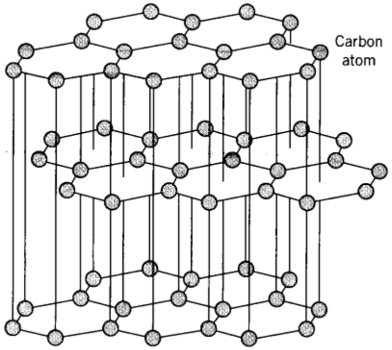
METALS

- IRON
- COPPER
- ALUMINIUM
- SILVER
- GOLD

CERAMICS

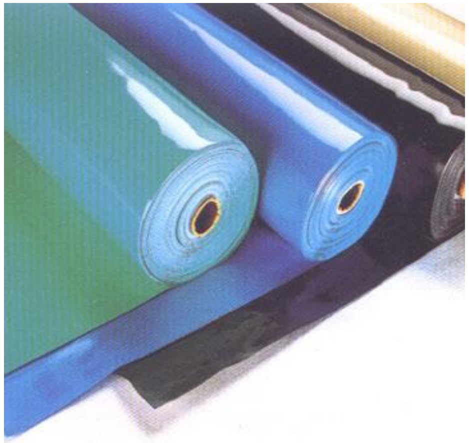
- SAND
- BRICK
- GLASS
- GRAPHITE





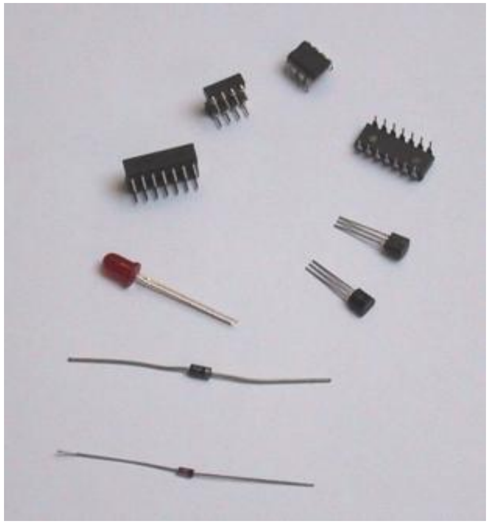
POLYMERS

- NYLON
- TEFLON
- POLYETHYLENE



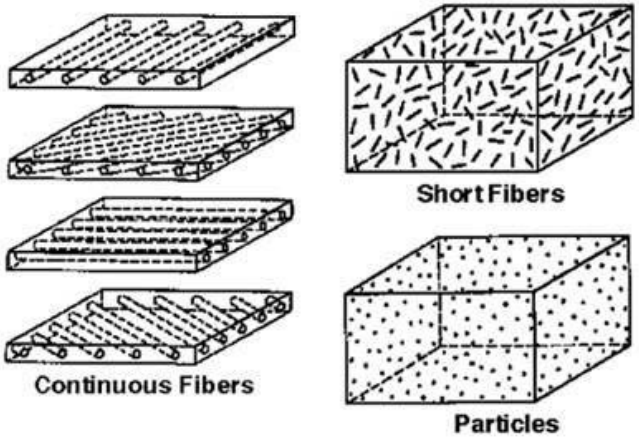
SEMI CONDUCTORS

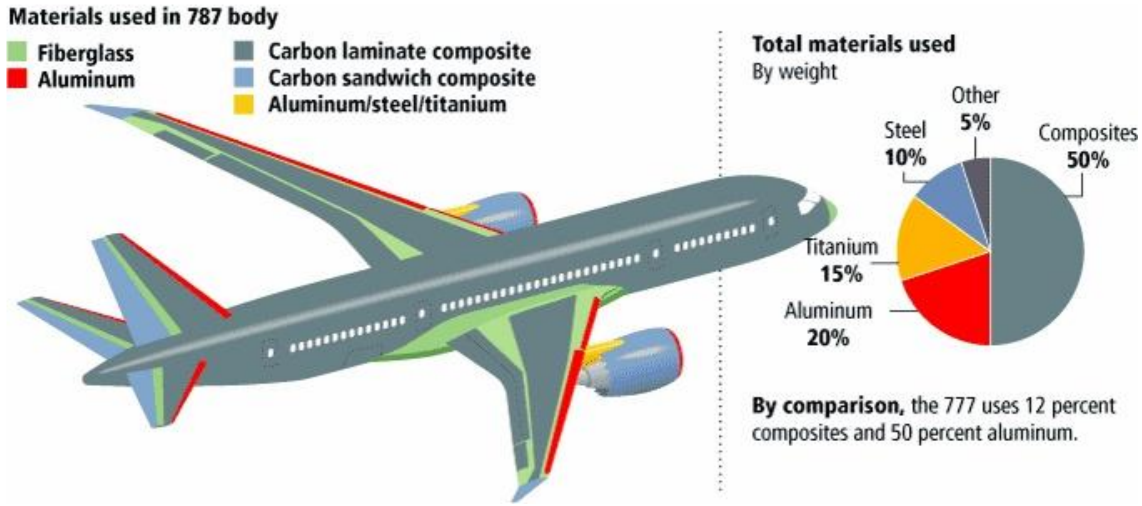
- SILICON
- GERMANIUM
- THESE ARE USED IN ELECTRONIC COMPONENTS LIKE TRANSISTOR AND INTEGRATED CIRCUITS



COMPOSITES

- COMPOSITES ARE MIXTURES OF MATERIALS SUCH AS CARBON FIBRES IN EPOXY MATRIX.
- IT IS USED IN TENNIS RACKETS





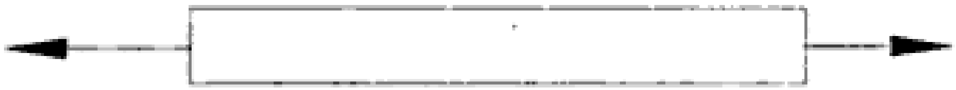
Properties of Materials

- MECHANICAL PROPERTIES
- ELECTRICAL PROPERTIES
- THERMAL PROPERTIES
- OPTICAL PROPERTIES
- MAGNETIC PROPERTIES

Mechanical Properties

Types of loads:

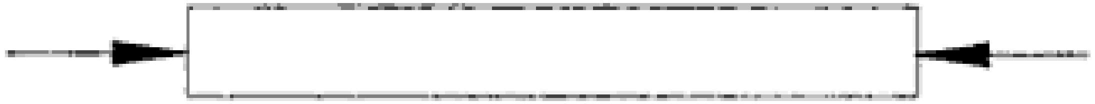
- When a body is subjected to two equal and opposite forces acting to pull the body, the body tends to elongate and is said to be in tension and the type of load applied is called **tensile load.**



(a) Tensile loading

Mechanical Properties(contd.)

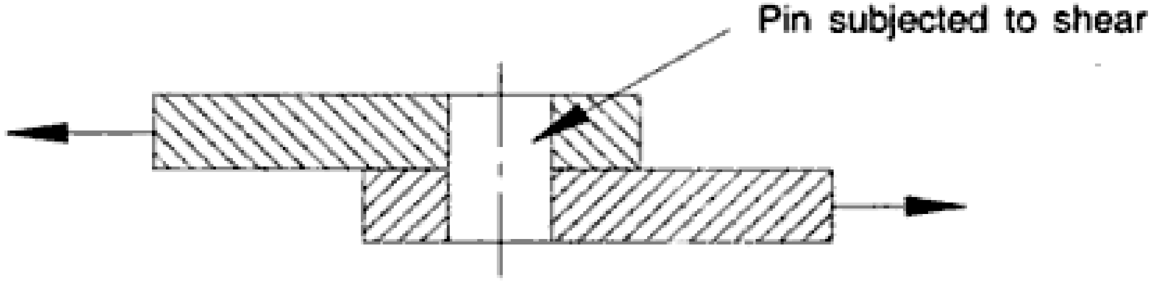
- When a body is subjected to two equal and opposite forces acting to push in to the body, the body tends to get shortened and is said to be under compression and the type of load is called **compressive load.**



(b) Compressive loading

Mechanical Properties(contd.)

- When a body is subjected to two opposite forces acting radially across the cross-section of the body. The body is said to be under shear and the type of load applied is known as shear load.



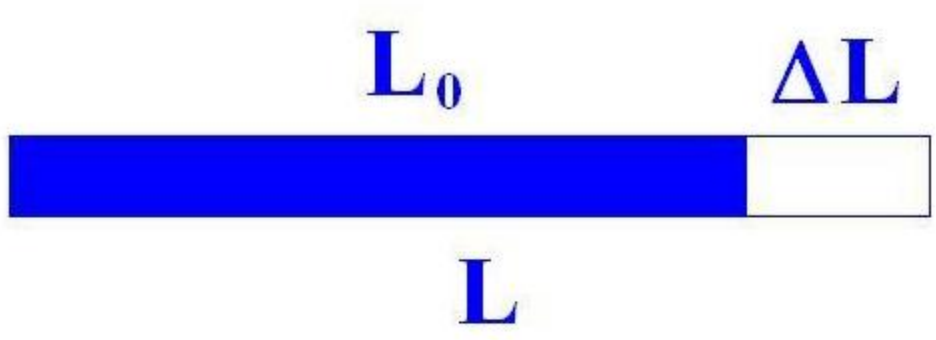
(c) Shear loading

Stresses

- Stress: Force per unit area (N/m^2)
- Depending upon the load applied, the stress developed in the material may be tensile, compressive or shear(also known as transverse) stress.

Strain

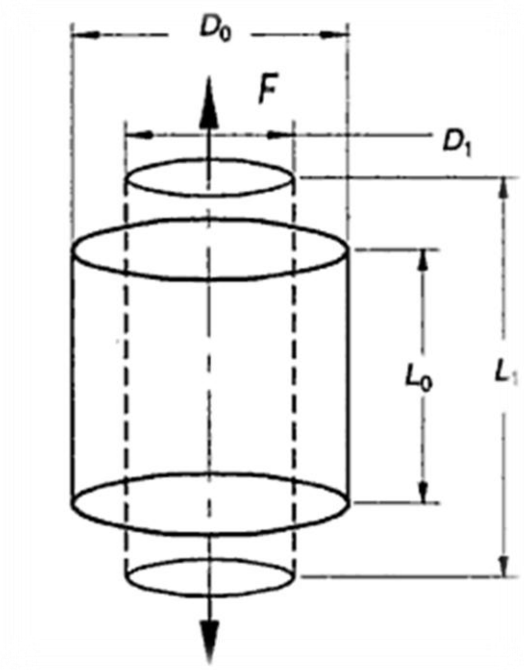
- The ratio of change in dimension to original dimension.
- It's a dimensionless quantity.



$$\varepsilon = \frac{L - L_0}{L_0} = \frac{\Delta L}{L_0}$$

The deformation of a cylinder under tensile loading

- A cylindrical specimen with original diameter Do and original length Lo subjected an axial force F. The Stress and Strain are defined as



$$\text{Stress } \sigma = \frac{F}{A_0}$$

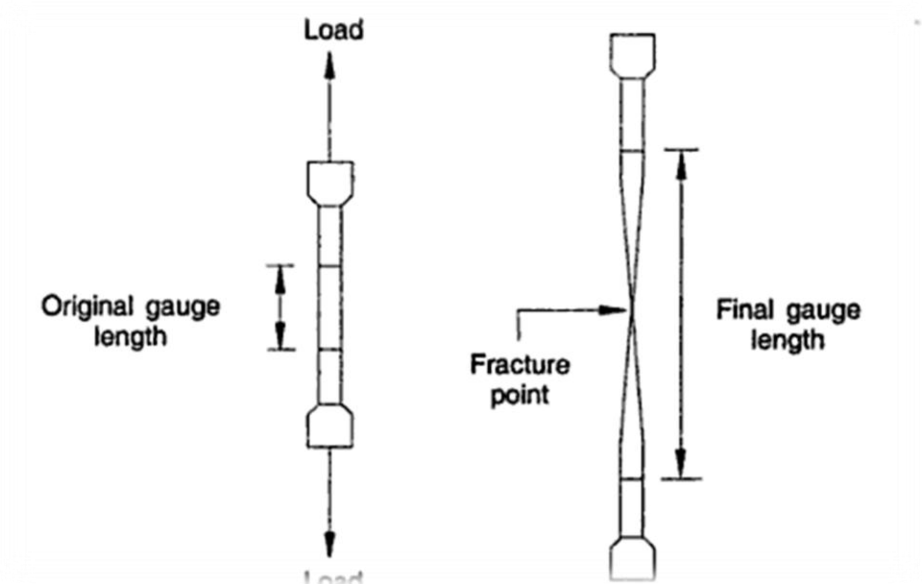
$$\text{Strain } \varepsilon = \frac{\Delta L}{L_0} = \frac{L_1 - L_0}{L_0}$$

Poisson's ratio

- The strain in the direction of applied load is known as linear strain or axial strain and the strain in the perpendicular direction is known as lateral or perpendicular strain.
- The ratio of lateral strain to linear strain is known as poisson's ratio.

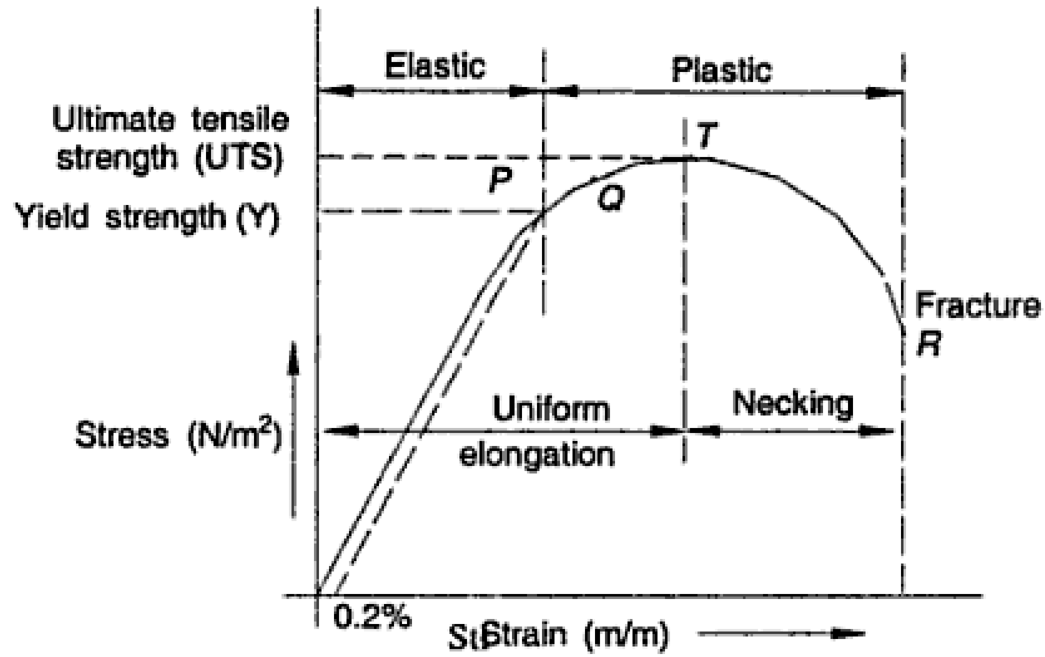
Stress – Strain Relationship

- Consider a cylindrical rod made of some ductile material of some specific length , is subjected to the continuously increasing tensile load of sufficiently high magnitude. The rod will go on elongation until it breaks.



Stress – strain curve

- The maximum stress from which the bar can return to its original length is the materials elastic limit, also called as proportionality limit



(a) Stress-strain curve for brass.

Stress – Strain curve(Contd.)

- The stress – strain curve is linear in the linear elastic region, is called Young's Modulus E.

$$E = \frac{\text{Stress}}{\text{Strain}} = \frac{\sigma}{\varepsilon}$$

- But,

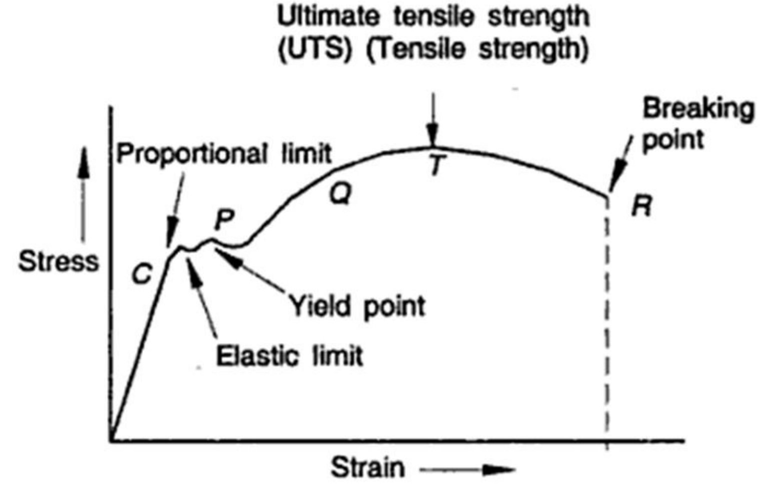
$$\text{Stress } \sigma = \frac{F}{A_0}$$

$$\text{Strain } \varepsilon = \frac{\Delta L}{L_0} = \frac{L_1 - L_0}{L_0}$$

Stress – Strain curve(Contd.)

$$E = \frac{\sigma}{\varepsilon} = \frac{F / A_0}{\Delta L / L_0} = \frac{F L_0}{A_0 \Delta L}$$

$$\Delta L = \frac{F L_0}{A_0 E}$$

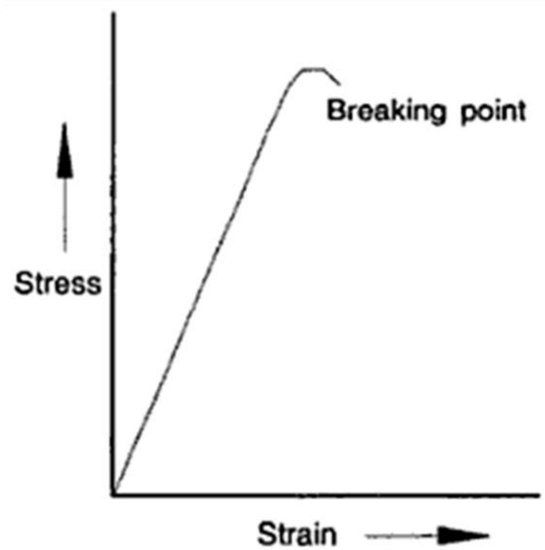


(b) Stress-strain curve for mild steel.

Yield point is defined as the first stress in the material at which an increase in strain occurs without an increase in the stress.

Stress – Strain curve(Contd.)

- The maximum stress that a bar will withstand before failing is the measure of its tensile strength, or ultimate tensile strength.



Stress-strain curve for a brittle material.

TOUGHNESS

- IS THE ABILITY OF THE MATERIAL TO WITHSTAND A SUDDENLY APPLIED LOAD AND THUS ABSORB A CERTAIN AMOUNT OF ENERGY WITHOUT FALURE

HARDNSS

- IS THE RESISTNCE OF THE MATERIAL TO MECHANICAL INDENTATION

DUCTILITY

- IS DEFINED AS TH EXTENT TO WHICH A MATERIAL CAN SUSTAIN PLASTIC DEFORMATION BEFORE RUPTURE

Brittleness

- A Material which undergoes a little rupture is called brittle.

Malleability

- It is the ability of the material to be flattened (deformed) in to thin sheets without cracking.

Resilience

- It is the ability of the body to absorb energy elastically.

Stiffness

- It is the ability of the material to resist deformation.

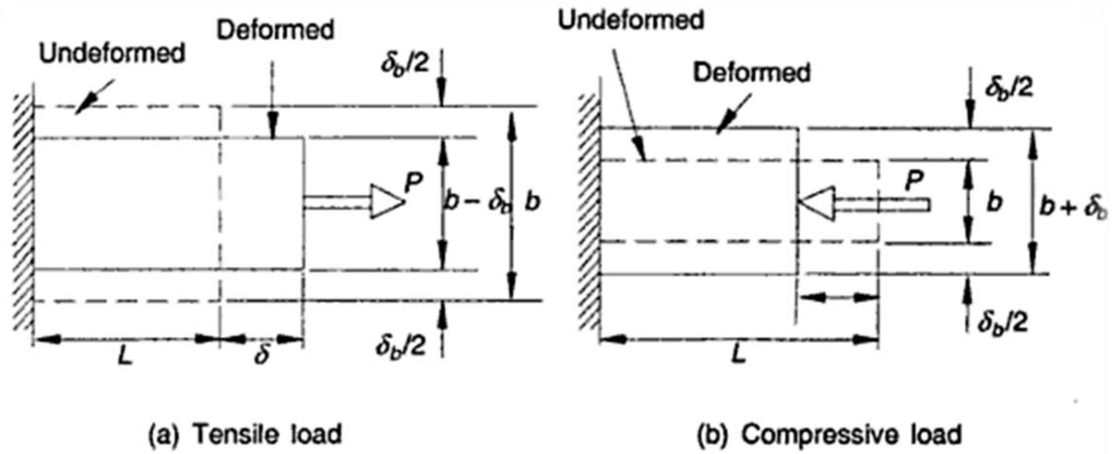
Poisson's Ratio

- The ratio of transverse strain to axial strain is constant for a given material with in the proportionality limit and this ratio is known as Poisson's ratio.

Axial strain $\varepsilon_a = \delta/L$

Transverse strain $\varepsilon_t = \delta_b/b$

Poisson's ratio $\nu = -\varepsilon_t/\varepsilon_a$



Bar subjected to an axial load.

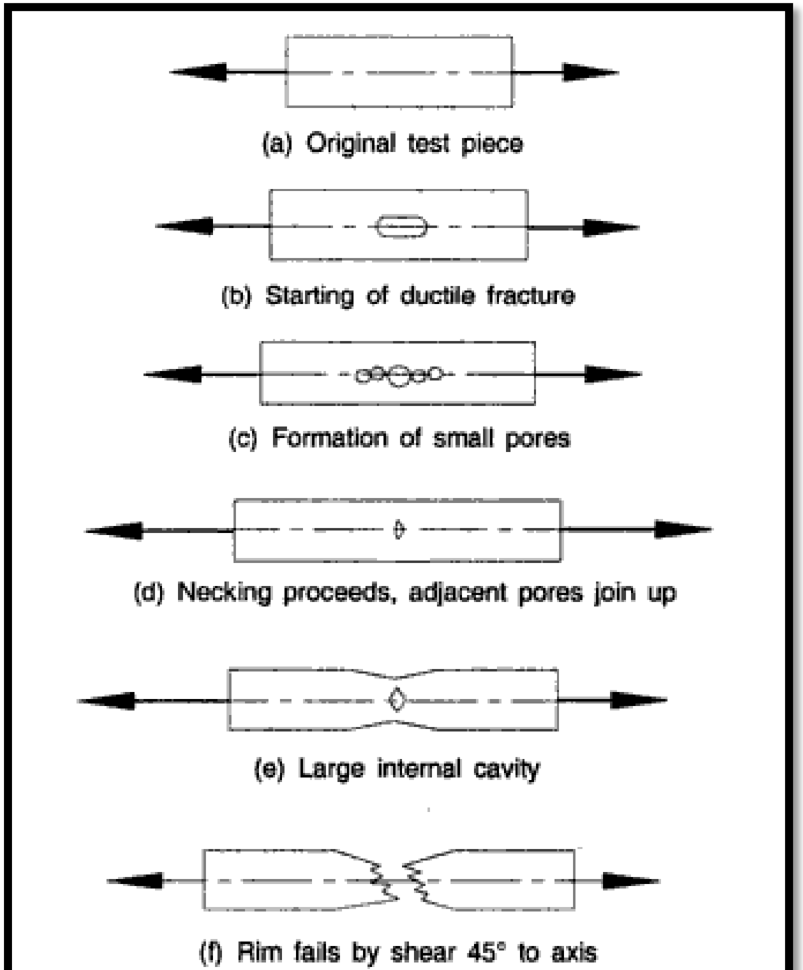
Modes of Facture

A **fracture** is the (local) separation of a body into two, or more, pieces under the action of stress.

In general facture mechanism is divided in to four classes:

1. Ductile
2. Brittle
3. Creep
4. Fatigue

Schematic development of ductile facture



Ductile Facture

If a material is subjected to load above yield point, process of deformation continues, fracture eventually occurs.

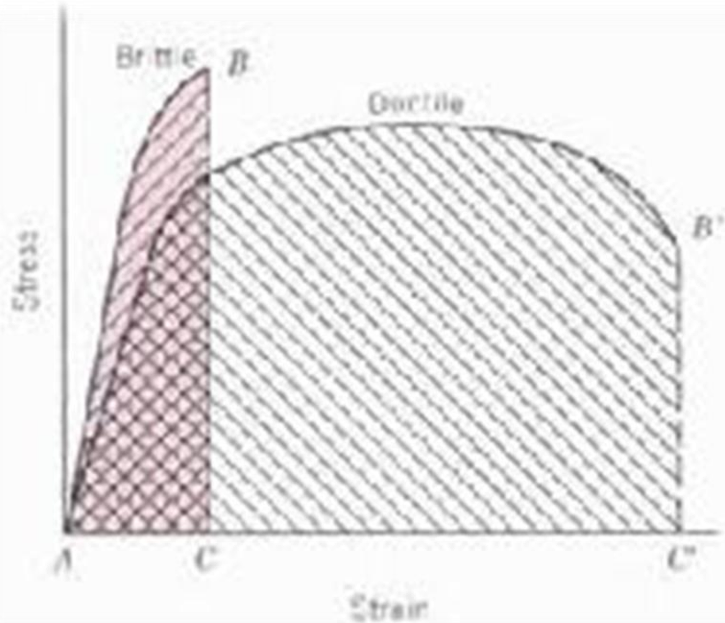
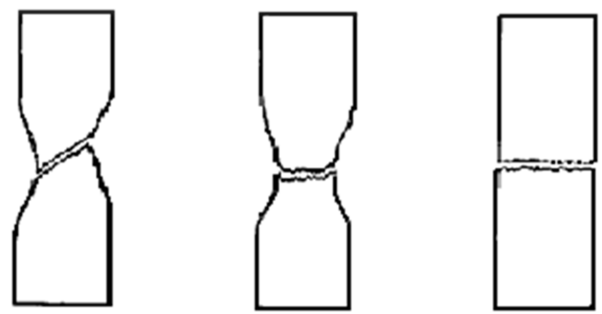


Figure 6.12 Schematic representations of tensile stress–strain behavior for brittle and ductile materials loaded to fracture.

Fracture of different materials



Ductile shear fracture in Aluminum

Ductile fracture in steel

Brittle fracture in steel

Brittle Facture

In Brittle Facture plastic deformation is not necessary for facture.

- Brittle factures may occur at stresses far below the yield strength, in the case of materials subjected to impact and shock loads and usually occur without warning

Creep Facture

In aggressive environments or at elevated temperatures, both stress strain behavior become time dependent.

- Creep can be defined as the plastic and inelastic distortion of the material subject to the long time loading or a continuing change in the deformation or deflection of a stressed member.

Fatigue fractures

Failure of a material due to cyclic or repeated stresses in the material

- Fatigue fractures occur at stresses well below the yield stresses, which the part can withstand under static conditions.

Factor of Safety

The factor of safety also known as Safety Factor, is used to provide a design margin over the theoretical design capacity to allow for uncertainty in the design process.

Factor of Safety

In choosing an appropriate value for the factor of safety, we need to consider the following :

- Variation in the mechanical properties due to non-uniformity/ non-homogeneity of the material
- Uncertainty in the method of analysis and method of manufacture
- Environmental conditions
- Type of application

Factor of Safety

For Ductile Materials:

$$\text{Factor of safety} = \frac{\text{Yield Strength}}{\text{Design stress}}$$

For Brittle Materials:

$$\text{Factor of safety} = \frac{\text{ultimate strength}}{\text{Design stress}}$$

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Common Engineering Materials

Commonly used engineering materials:

CAST IRON:

- It is a ferrous metal, an alloy of iron with 2.1 to 4.5 % carbon and 3.5 % Silicon.
- Graphite is present in cast iron in free form and it adds self-lubricating properties to cast-iron.
- cast-iron has good compressive strength, damping property and is weak in tension.
- Some of the types of cast iron are gray cast iron, malleable Cast iron, spheroidal- cast iron and so on.

STEEL:

- it is an alloy of iron and carbon, in addition, it may contain other alloying elements such as manganese, silicon, chromium and copper.
- Steel is classified on the basis of carbon present in to three groups

1. Low carbon steel or mild steel

   (0.05 to 0.3% C)

2. Medium carbon steel

   (0.3 to 0.7% C)

3. High Carbon Steel

   (0.7 to 1.5% C)

Application of Carbon Steels

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Applications of Carbon Steels

Common name	Carbon % content	Applications
Low carbon	0.05–0.125	Thin sheets, tubes, wire.
	0.15–0.3	Structural sections, boilers, general purpose applications.
Medium carbon	0.3–0.5	Agriculture implements, wheel axles, tubes and wires.
	0.5–0.7	Hammers and other hand tools, wheel rims, springs, dies.
High carbon	0.7–0.9	Cutting blades, chisels, dies.
	0.9–1.1	Wood working tools, dies, chisels, cutting tools.
	1.1–1.5	Metal cutting tools, razor blades, files, drills, gauges.

Aluminium

- Aluminium is a non ferrous material
- It is an excellent thermal and electrical conductor and has very good resistance to corrosion.
- Aluminium weighs about one third of steel and possesses very good ductility.
- Applications of aluminium are in packaging, consumer durables, utensils, electrical appliances etc.,

Copper

- It is a non ferrous metal.
- It is also an excellent conductor of heat and electricity and has good corrosion resistance.
- It is soft, tough, easy to mould, and is suitable for working in both hot and cold conditions.
- Brass is an alloy of copper and zinc.
- Bronze is an alloy of copper and tin.

Lead:

- It is very durable and versatile material.
- It has properties of high density and easy work ability
- It has resistance to corrosion and many acids have no chemical action on it.
- In soldering process an alloy of lead and tin is most widely used.

ZInc:

- Zinc & Zinc alloys have low Melting point.
- Examples : Carburetors, fuel pumps, automobile parts and so on.

Tin:

- Tin is a soft and ductile material
- It posses very good malleability.
- Application in tin cans for storage.

Selection of Material

The step wise approach for the selection of material is as follows:

Step 1: Define material requirements

Material requirement can be defined by keeping in view overall objectives of the part for which the selection of material is made.

Selection of Material

Step 2: Find the possible material (s)

The material requirements identified may be met by number of materials. Make a list of all such materials that meet all or most of the requirements.

Step 3: Make a choice

in case when more than one materials appears to be suitable, the final choice should be determined by considering influencing factors and restrictions like availability of raw material, cost and so on.

Problems

1. A steel rod having 10 mm diameter and 1.5 m length is subjected to an axial pull of 1 KN.

Find

a) stress,

b) strain, and

c) elongation.

Assume modulus of elasticity

$E = 205 \text{ X } 10^6 \text{ kN/m}^2$.

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Prob 1 contd.

- Given

D = 10 mm,

L = 1.5 m,

F = 1kN

$E = 205 \times 10^6 \ kN/m^2$

Cross-sectional area = $A = \Pi D^2/4$

$= \Pi (10 \times 10^{-3})^2/4$

$= 7.85 \times 10^{-5} \ m^2$

Prob 1 contd.

a) Stress = F/A

$=1 \text{ X } 10^3/7.85\text{X}10^{-5}$

$= 1.27 \text{ X } 10^7 \text{ N/m}^2$

b) Strain = stress/E

$=(1.27 \text{ X } 10^7)/(205 \text{ X } 10^6)$

$= 6.21 \text{ X } 10^{-5}$

c) Elongation = strain/L

$= 6.21 \text{ X } 10^{-5} \text{ X } 1.5$

$= 9.32\text{X } 10^{-5} \text{ m}$

Prob 2 contd.

- The following data were obtained during the tensile test of a steel specimen having 30 mm diameter and 200 mm length.

Extension at a load of 50 KN = 0.1 mm

Load at elastic limit = 230 kN

Maximum load = 300kN

Total extension = 50 mm

Diameter of rod at failure = 20 mm

Calculate

a)Young's modulus

b) Percentage elongation, and

c) Percentage decrease in area.

Prob 2 contd.

- Given:

$D = 30$ mm

$F = 50 \times 10^3$ N

$L = 200$ mm

$\Delta L = 0.1$ mm

$d = 20$ mm

Then,

Area $= A = \Pi D^2/4 = \Pi\,(30)^2/4$

$= 706.86 \times 10^{-6} m^2$

Prob 2 contd.

Stress = F/A =7.07 X 10^7 N/m^2

Strain = ΔL / L = 0.1/200 = 0.0005

a) Young's modulus = E = stress/strain

= 14.14 X 10^{10}N/m^2

b) Percentage elongation =

= (inc. length/org. length)X100

= 50/200X100 = 25%

Prob 2 contd.

c) Percentage Decrease in Area

=(decreased area/original area)X100

$= (D^2-d^2/D^2)$ X 100

$= (30^2-20^2/30^2)$ X 100

= 55.55 %

Prob 3

- A short timber post of rectangular cross-section has side of section twice the other. When the timber post is subjected to compressive load of 10KN, it contracts by 0.0521 mm for 1m length. If the modulus of elasticity of timber is 12 Gpa, Calculate the dimensions of the post.

Prob 3 contd.

- Given :

$F = 10X10^3N$

$\Delta L = 0.0521\ X10^{-3}\ m$

$E = 12\ X\ 10^9 N/m^2$

$L_o = 1m$

$\Delta L = Flo/AE$

$A = 0.015994\ m^2$

Prob 3 contd.

Let one side of rectangular cross section is b

the other side of rectangle d = 2b (given)

Hence A = bXd = bX 2b = $0.016 m^2$

b = 0.089 m and d = 0.178 m

Prob 4

- A 20 mm diameter and 200mm length brass rod was subjected to tensile load of 40KN. The extension of the brass rod was found to be 0.254 mm. Find the Young's Modulus of the bar.

- D = 20 mm = 20X 10 -3
- L = 200 mm = 200 X 10 -3
- F = 40 KN
- ΔL = 0.254 mm.
- E = ?

Prob 5

- A wooden tip is 50 mm wide, 100 mm deep and 2 m long. It is subjected to an axial pull of 50KN. The strength of the member is found to be 0.65 mm. Find the young's modulus of the material.