

- # **Elasticity** :- The property of a body by virtue of which it regains its original shape and size after removal of external force or deforming. Elastic body force is called Elasticity.
- **Elastic body** :- Those material which can gain their original position after removal of deforming force are called elastic body. For ex: quartz crystal, Steel, Copper,
- **Plastic body** :- Those material which can't gain their original position after removal of deforming force are called plastic body.
- # **Plasticity** :- The property of a body in which body can't regain its original shape and size after removal of external or deforming force is called plasticity.

Rigidity :- The property of material which offers resistance to a deforming force.

Rigid body:-

Reforming Force :: Restoring Force.

$$F_{ext} = F_R$$

Stress: σ : The restoring force per unit area.

$$\sigma = \frac{F_R}{A}$$

unit :- N/m^2 . (Tensor quantity) # Rank: 2 (Scalar quantity for Macro)

- Difference between Pressure AND Stress.

Pressure

Stress

① Pressure can be defined as the amount stress can be defined as the internal force applied per unit area. resistive force to the deformation

1 Pressure is always ↓ per unit area
 ② Stress may be tensile, compressive stress may be tensile, compressive, shear & shear

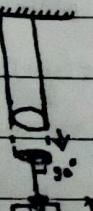
③ Stress is developed internally pressure is exerted externally
 ④ the pressure is always positive true stress can be either positive or negative

- Types of Stress:

① Longitudinal Stress OR Normal Stress: The force acting normally to the cross-sectional area.

- The stress developed on an elastic body when normal deforming force acting on a body per unit area.

$$[M^{-1}T^{-2}]$$



F_N Normal

- Tensile stress :- The deforming force acting normally to the cross-sectional area of an elastic body to increase the length of the body.
- Compression :- The deforming force acting normally to the cross-sectional area of an elastic body to decrease the length of the body.

(i) Bulk stress :- The stress which is developed on entire surface of the body when deforming force when applied to change the volume of the body is called bulk stress.

It is also known as Volumetric stress.

(ii) Tangential or Shearing stress : The tangential stress is defined as the tangential force acting on an elastic body per unit area is called tangential or shearing stress.

\Rightarrow defined as the ratio of force acting tangentially on the surface to the area of surface.

Strain (ϵ)

The ratio of change in configuration to original configuration of an elastic body is called Strain.

$$\therefore \epsilon = \frac{\text{change in dimension}}{\text{original dimension}}$$

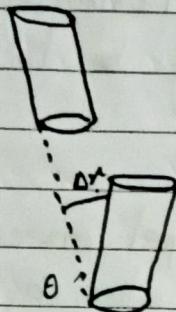
$$\text{or } \epsilon = \frac{\Delta L}{L} \text{ or may be } \epsilon = \frac{\Delta x}{x}$$

Types of Strain

- Longitudinal strain :- The ratio of change in length to the original length $\epsilon_L = \frac{\Delta L}{L}$

- Bulk strain :- The ratio of change in volume to the original volume $\epsilon_V = -\frac{\Delta V}{V}$ of a body due to deforming force is called Bulk strain.

① Shear strain / Tangential Strain :- The strain in which the angle between vertical line and surface gives tangential strain in presence of shear / tangential force



$$\tan \theta = \frac{\Delta x}{x}$$

for very very small angle

$$\tan \theta \approx \theta$$

$$\theta = \frac{\Delta x}{x}$$

Hooke's law :- within the proportional limit, elongation produced on a body is directly proportional to restoring force

$$e \propto -f$$

$$e = \frac{1}{k} f$$

$\therefore f = -ke$ where $F = \text{restoring force}$

$k = \text{force constant / spring constant}$

$e = \text{elongation}$

$F(e) = \text{restoring force}$.

Here, # are ... ①

$$\frac{F}{A} \propto \frac{e}{l}$$

$$\frac{F}{A} \times l = \frac{k e}{A} \times \frac{l}{l}$$

$$\therefore \frac{F}{A} = \frac{\Delta l}{l} : e$$

$$\frac{F}{A} = \frac{k l}{A} \times \frac{e}{l}$$

$\therefore \text{Stress} \propto \text{strain} \quad \text{--- } ②$

$\therefore \text{Stress} \propto \text{strain}$

$c = \text{Stress / strain} \quad \text{--- } ③$

Hooke's law is also defined as Stress produced on an elastic body is directly proportional to the strain within proportional limit

Force constant is defined as deforming force per unit elongation. It is constant quantity but depends on nature material.

$$\text{Slope (m)} = \frac{F_2 - F_1}{e_2 - e_1}$$

$$= \frac{\Delta F}{\Delta e}$$

$$\therefore k = \frac{\Delta F}{\Delta e} \parallel$$

$$F = ke$$

$$y = mx$$

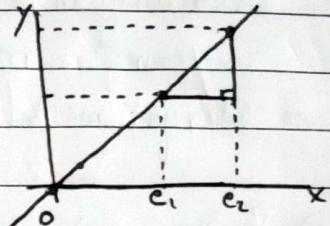


Fig:- Fe curve...

The slope of st line of fe curve gives force constant or spring constant.

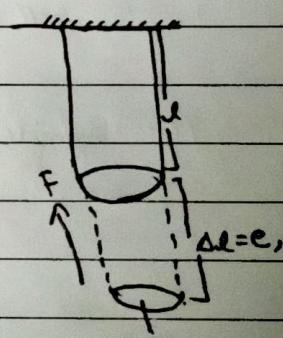
Types of modulus of elasticity

@ The ratio of normal stress to longitudinal strain of an elastic body is called young's modulus of elasticity.

$$Y = \frac{\text{Normal Stress}}{\text{longitudinal Strain}}$$

$$Y = \frac{F/A}{e/l}$$

$$\therefore Y = \frac{\Delta e}{\Delta l} \frac{F l}{A e}$$



Young's modulus is constant quantity but depends on nature of materials. and it is only applicable in ~~only~~ solid. [unit is:- N/m²]

For perfectly elastic body

$$e=6, Y=\infty$$

For perfectly plastic body

$$e=\infty, Y=0$$

why is steel more elastic than rubber?

\Rightarrow Steel is more elastic than rubber because the rate of elongation is lower than the rubber. Since, Young's modulus is indirectly proportional to the elongation ($\propto \frac{1}{E}$) so, steel is more elastic.

⑥ Bulk modulus.

The ratio of Bulk stress to the Volumetric Strain can be defined as the bulk modulus.

It is applicable in all solid, liquid & gas

$$\text{Bulk modulus (B)} = \frac{F}{A}, \quad \frac{F \times V}{A \times \Delta V}, \quad \frac{\Delta V}{V}$$

$$B = \frac{P V}{\Delta V}$$

$$\text{Compressibility : } C = \frac{1}{B}$$

$$\therefore C = \frac{\Delta V}{P V}$$

⑦ Shear / tangential modulus of elasticity : - The ratio of Bulk Stress to the Shear Strain is defined as Shear / tangential modulus.

$$\eta = \frac{F}{A} = \frac{F \times n}{A \times \Delta n}$$

$$\frac{\Delta n}{n}$$

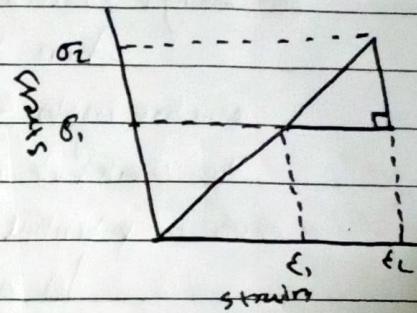
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$$\# \eta \approx Y_3 \gamma$$

Stress-Strain Curve

$$m = \frac{\sigma_2 - \sigma_1}{\epsilon_2 - \epsilon_1}$$

$$y = \frac{\Delta \sigma}{\Delta \epsilon} = \frac{\text{change in stress}}{\text{change in strain}}$$



The curve which is obtained by plotting stress on y-axis and strain on x-axis is called Stress-Strain curve.

OA region :- Hooke's law is obeyed

AB region :- Shows elastic nature but doesn't obey hooke's law

BC : Strain increases rapidly but Stress is almost constant

CD : Strain and stress increases rapidly.

DE : Strain increases but stress decreases.

A:- proportional limit (Stress \propto strain)

B:- elastic limit D:- Breaking point.

C:- yield point E:- fracture point.

\Rightarrow The maximum limit up to which an elastic body shows nature of elasticity is known as elastic limit beyond this limit. A body shows plasticity

\Rightarrow Breaking stress : The maximum stress which is required to cause the actual break of the body is called Breaking stress. It depends on nature of materials but not on dimension.

$$\sigma_{\max} = \frac{\text{Breaking force}}{\text{Area}} = uts \text{ (ultimate tensile stress)}$$

Energy stored in wire.

When tensile force is applied in a wire then a wire gets stretched and stress is produced on wire. The work done against internal restoring force is stored as a potential energy or strain energy.

Let's consider a uniform wire of length(l) and cross-sectional area(A) is suspended from right support. Let (F) be the force applied on the wire to produce elongation as (x) now, the young's modulus of given material is given by

$$Y = \frac{F \cdot l}{A \cdot e} \quad \text{or} \quad Y = \frac{F \cdot l}{A \cdot x} \quad \dots \quad (i) \quad \therefore F = \frac{YA}{l}x \quad \dots \quad (ii)$$

The small work done from $x=0$ to $x_1=e$ is given by

$$\text{Since, } dW = F \times dx$$

$$dW = \frac{F \cdot l}{A \cdot x} dx \quad dW = \frac{YA}{l} x \times dx \quad \dots \quad (iii)$$

$$\therefore W = \int_{0}^{e} \frac{YA}{l} x dx$$

$$\therefore W = \frac{YA}{l} \int_{0}^{e} x dx$$

$$\therefore W = \frac{YA}{l} \left[\frac{x^2}{2} \right]_{0}^{e} \quad \therefore W = \frac{YA}{l} \left(\frac{e^2}{2} - \frac{0^2}{2} \right)$$

$$W = \frac{YA}{l} \times \frac{e^2}{2}$$

$$W = \frac{1}{2} \times \frac{YA}{l} \times e^2$$

$$W = \frac{1}{2} \times F \times e,$$

This is required eqn of energy stored in a stressed wire as a potential energy.

Energy density:- Energy density is defined as energy stored in a wire per unit volume.

$$U = \frac{V}{V} = \frac{U}{A \times l}$$

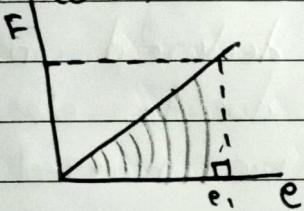
$$= \frac{Y_2 \times F \times e}{A \times l}$$

$$= \frac{1}{2} \times \frac{F}{A} \times \frac{e}{l}$$

$$= Y_2 \times \text{stress} \times \text{strain}.$$

This is required eqn for energy density. It is found that energy density is the half of product of stress & strain.

Fe curve,



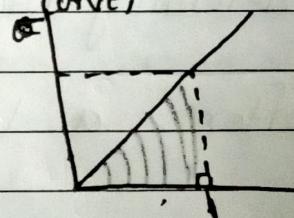
$$A = Y_2 \times b \times h$$

$$= \frac{1}{2} \times e \times F$$

= Energy stored or work done,

$$\text{Slope} = \frac{\Delta F}{\Delta e} = \text{Spring constant},$$

of curve,



$$A = Y_2 \times b \times h$$

~~$$= \frac{1}{2} \times e \times F \times Y_2 \times \text{stress} \times \text{strain}$$~~

= Energy density,

$$\text{Slope} = \frac{\Delta F}{\Delta e}$$

IT values range from -1 to 0.5, similarly practically IT values mostly lies betw 0.2 to 0.4 or 0.5

classmate

Date _____

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Elastic After effect.

Elastic after effect is the highest for glass & least for quartz, phospher, bronze.

⇒ The temporary delay in regaining its original position after removal of deforming force is called elastic after effect.

⇒ While phospher-bronze is used in galvanometer.

Elastic Fatigue :- The loss of elastic strength of an elastic material due to frequent alternating deforming force is called elastic fatigue.

Effects: The bridge is declared unsafe after a long continuous use due to elastic fatigue.

The spring balance incorrect reading after a continuous use.

Question: The bridge is declared as unsafe after a long use.
The spring balance shows incorrect reading after a long use?

The ratio of change in diameter (Δd) to original diameter (d) is called lateral strain.

$$\beta = \frac{\Delta d}{d}$$

$\Delta d = d_0 - d_1$ define diameter decrease.

The ratio of change in lateral strain to the longitudinal strain of an elastic body is called Poisson's Ratio (σ)

$$\sigma = \frac{\frac{\Delta d}{d}}{\frac{e}{l}} = \frac{\Delta d}{d} \times \frac{l}{e}$$

$$\therefore - \frac{\Delta d}{d e}$$

Factors effecting elasticity.

① Temp (Annealing)

$$\gamma = F/A \alpha \Delta \theta$$

② Hammering & Rolling ↑

③ Impurity.

⇒ The bridge is declared as unsafe after a long use because

the metal used in construction of bridge lose the elastic gradually due to continuous use due to which the probability of fracture in bridge and accident gets higher. So, to minimize the accident bridge are declared unsafe.

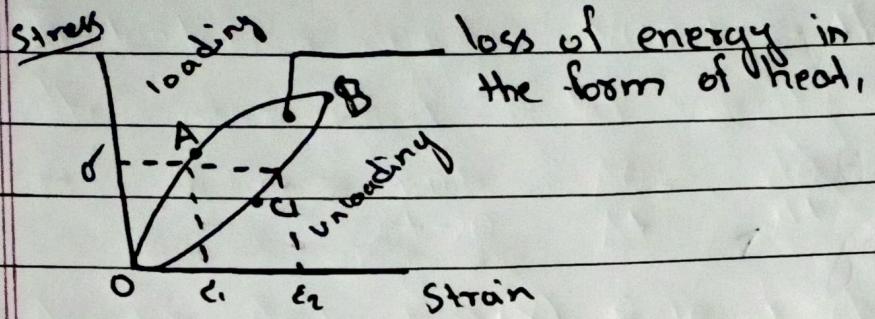
⇒ The spring balance shows incorrect reading after a long use because the spring made of elastic material lose elastic nature due to which high elongation is produced on a spring at a minimal force. So, the spring become incorrect.

Ductometer :- Elastometer is a material that doesn't obey Hooke's law within elastic limit for eg: Rubber.

The stress is lagging behind of strain is called elastic hysteresis. It is due to elastic after effect.

- The loading & unloading path of material can't be retraced

The shaded part represents loss of energy in the form of heat.



question The tyre of a car is made by using synthetic rubber . why ?
 Question why are O used as vibration absorber ?

\Rightarrow The tyre of a car is made by using synthetic rubber because the material made up of synthetic rubber