UNIT – I PROPERTIES OF MATTER

TOPIC – II : Types of Elastic Modulus

Types of Modulus

Corresponding to the three types of strains, there are three elastic modulus:

1. Young's modulus : It corresponds to linear or tensile strain.
2. Bulk modulus : It corresponds to volumetric strain.
3. Rigidity modulus : It corresponds to shearing strain.

Young's Modulus (Y)

It is defined as the ratio of longitudinal stress to longitudinal strain within elastic limits. Let a wire of length 'L' and area of cross section 'a'. one end of the wire is fixed in the top and a load is applied on the bottom of the wire as shown in Fig.2.

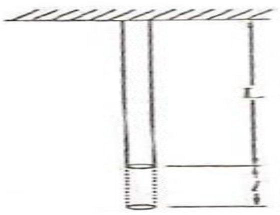

Fig.2 Change in Length

The force which is acting along the length of the wire is 'F'. Let the increase in length is 'l' when a stretching force 'F' is applied in the direction of its length. The force applied per unit area of cross section is known as longitudinal or linear stress. The ratio of the longitudinal stress to linear strain within the elastic limit is known as Young's modulus.

Longitudinal strain = l/L

Stress = F/a

∴ Young's modulus Y = stress/ strain

$$\mathbf{Y = FL/al}$$

Unit of the Young's modulus is Nm^{-2} or Pascal.

Bulk Modulus (K)

It is defined as the ratio between volume stress to the volume strain. Consider a body of volume 'V' and area of cross section 'a' as shown in Fig.3. Let 'F' be the force applied under normal condition to the whole surface of the body. This results in change in volume but there is no change shape of the body.

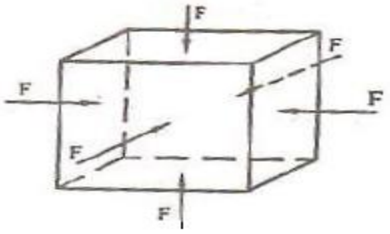

Fig.3 Change in Volume

When three equal stresses (F/a) are act on a body in mutually perpendicular directions, such that there is a change of volume ΔV in its original volume.

Volume stress = F/a

Volume strain = - (ΔV/V)

∴ Bulk modulus K = Volume stress/ Volume strain

= - (PV/ΔV)

The negative sign indicates that the pressure is increased with increasing volume.

Rigidity Modulus

It is defined as the ratio of tangential stress to shearing strain.

Consider a solid cube ABCDEFGH as shown in Fig.4. The lower face CDEF is fixed and a tangential force F is applied over the upper face ABEF. The result is that each horizontal layer of the cube is displaced, the displacement being proportional to its distance from the fixed plane. Point A is shifted to A′, B to B′, E to E′ and F to F′ through an angle ϕ, where AA′ = EE′ = l.

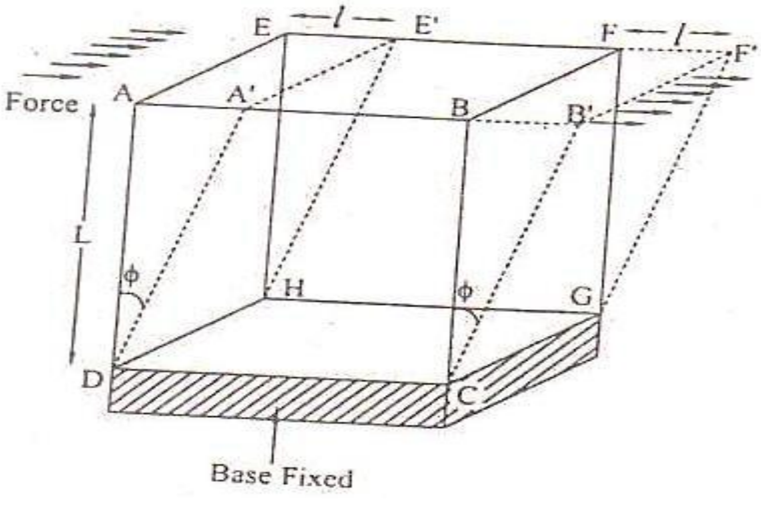

Fig.4 Change in Angle

Clearly ϕ = (l/L), where l is the relative displacement of the upper face of the cube with respect to the lower fixed face, The angle ϕ is a measure of the shearing strain.

Now, Rigidity modulus (G) = $\frac{Tangential\ stress}{Shearing\ strain}$

Rigidity modulus (G) = $\frac{F}{a\phi}$

Here, a = L^2 = Area of face ABEF.

Rigidity modulus (G) = $\frac{T}{\phi}$

Where T is a tangential stress.