Elastic Modulii

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- Modulus of elasticity is a measure of elasticity of a material ie how difficult to deform a material.
- There are different types of elastic modulii depending upon the deformations produced in the body.

Young's Modulus(Y)

- It is used to characterize the stretchability of a material.
- Consider a wire of length "L" and area of cross section A.
- If stress is applied longitudinally, there will be a elongation ΔL.

- Then, Within elastic limit ,

Young's Modulus= $\dfrac{Linear\ stress}{Linear\ strain}$

$$= \frac{F/A}{\Delta L/L} = \frac{FL}{A\Delta L}$$

- Young's Modulus is also called *Tensile Modulus.*
- *Since strain is unitless, Y has the unit of stress.*
- *Unit of Young's Modulus is N/m^2 or Pascal*

Bulk Modulus(B)

- When a material is subjected to compressive forces ,there will be changes in Volume.
- The force per unit area applied normally and uniformly to the surface of the body(Pressure)
- Within elastic limit ,the ratio of normal stress (pressure) to the volume strain is called Bulk Modulus.

- Bulk Modulus ,B= $\dfrac{Normal\ stress}{Volume\ strain}$

$$= -\frac{F/A}{\Delta V/V} = -\frac{PV}{\Delta V}$$

The minus sign indicates that pressure and volume are in opposite relation.In this way B kept positive.

- Unit of Bulk modulus is same as that of pressure or Young's Modulus ie N/m^2 or Pascal.

- The reciprocal of Bulk Modulus is known as Compressibility(C) where C=1/B

- Unit of Compressibility=m^2/N

Rigidity Modulus(n)

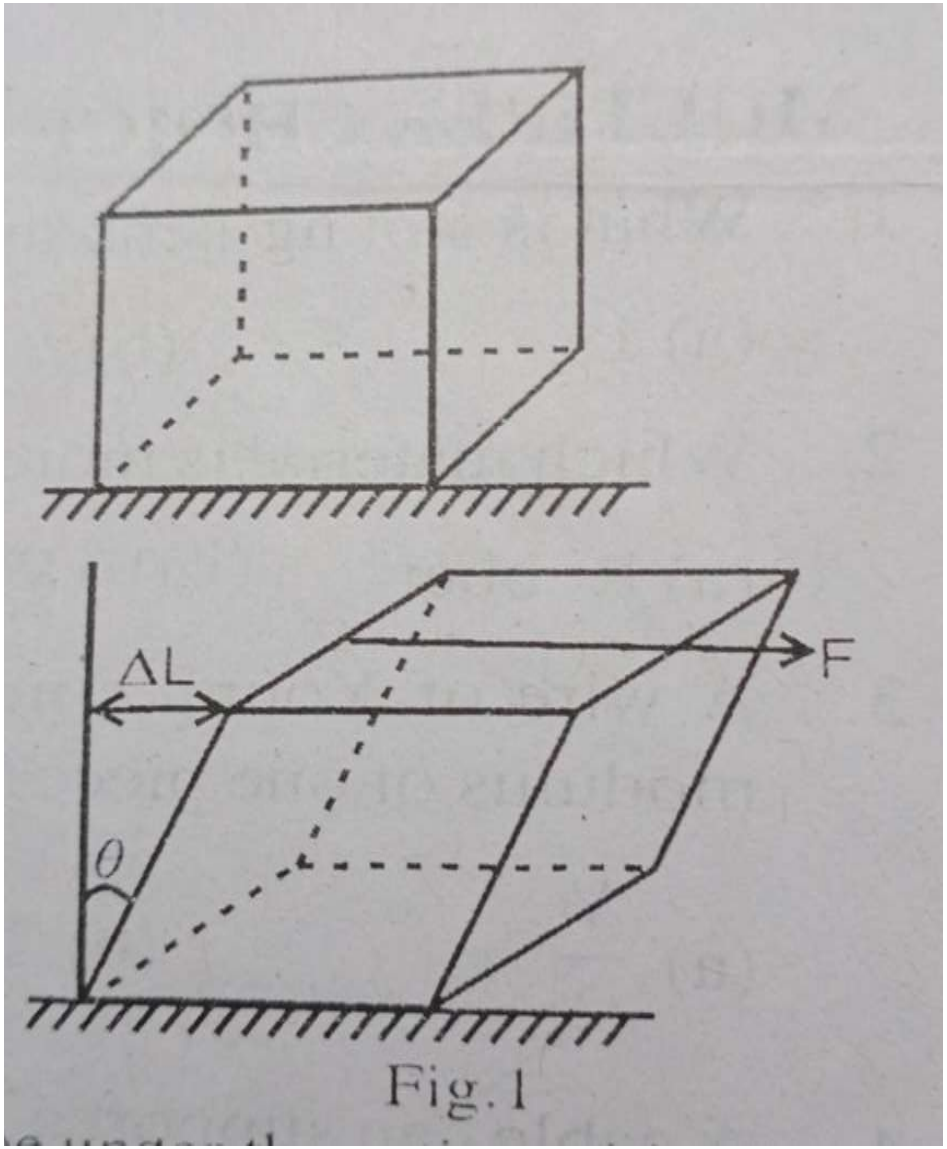

Fig. 1

- A cube of side with its lower end fixed on a table. A force is applied parallel to its top deforms it through an angle θ.
- Here strain= θ=ΔL/L
- Within elastic limit, Rigidity Modulus,n=Shearing stress/shearing strain
- n=stress/ θ

Rigidity Modulus , $n = \frac{F/A}{\theta} = \frac{F/A}{\Delta L/L} = \frac{FL}{A\Delta L}$

Although the expression is same for youngs modulus and rigidity modulus, the two represents different physical characteristics.

Unit of Rigidity modulus= N/m^2(Same as that of Youngs Modulus and Bulk Modulus)

Table 1 Elastic parameters

All numerical values are expressed in units of GPa

Material	Y	n	B
Tungsten	350	140	200
Steel	190-200	84	160
Copper	100-130	42	140
Aluminium	70	25	70
Brass	91	35	61
Quartz	56	26	27
Wood	10-13	-	-
Rubber	0.004	-	-
Water	-	-	2.1
Air (at STP)	-	-	10^{-4}

1 GPa = 10^9Pa

Stress Vs Strain Graph

- Linear region
- Range of permanent deformation
- Ultimate strength(repturing occurs)

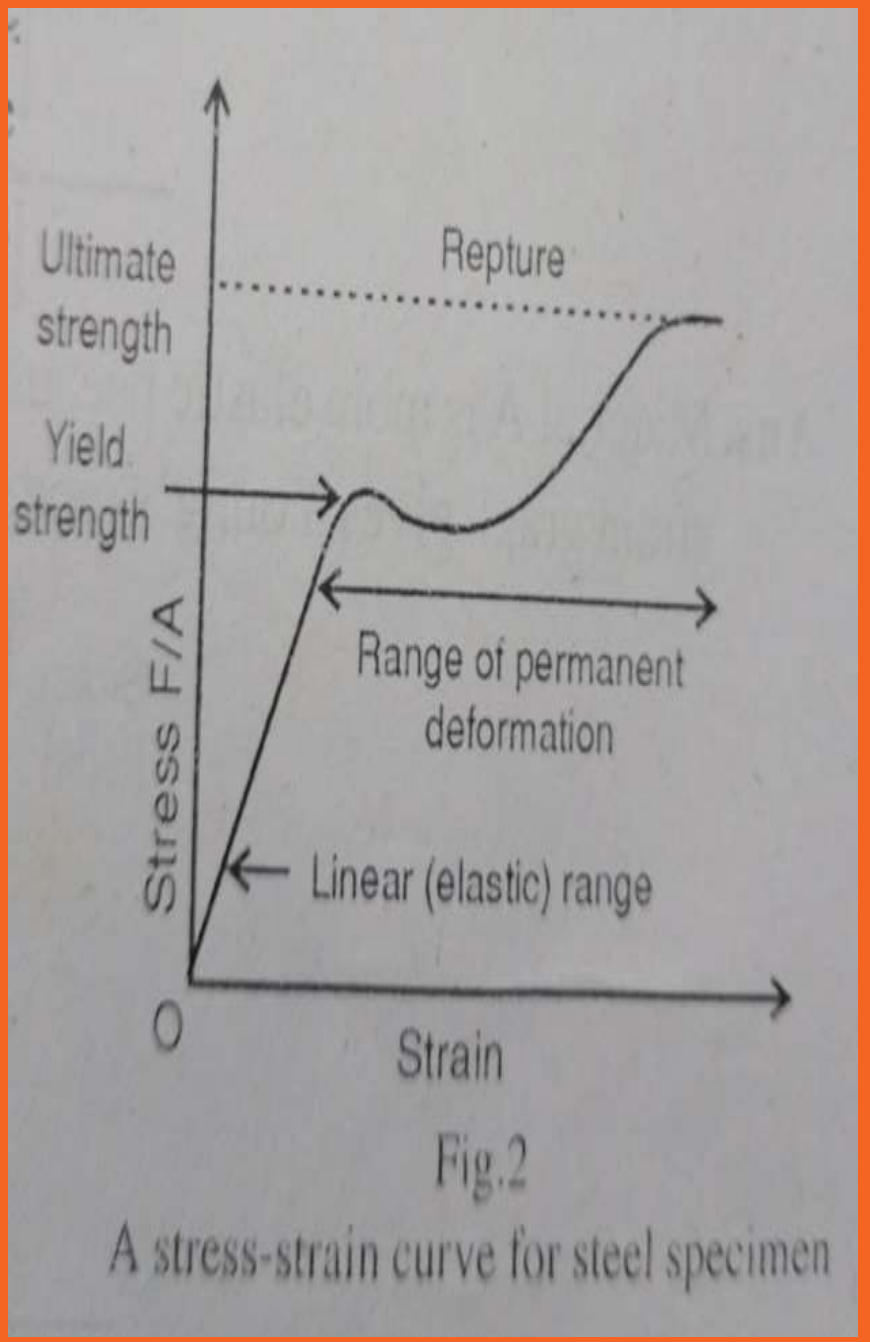

Fig.2

A stress-strain curve for steel specimen

- Slope of stress-strain graph in the linear portion gives the modulus of elasticity.

- For a material of less Young's modulus ,the graph will incline more to the strain axis.

THANK YOU