SNS COLLEGE OF TECHNOLOGY

Coimbatore-35
An Autonomous Institution
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DEPARTMENT OF CIVIL ENGINEERING

19CET203- Mechanics Of Solids

II YEAR III SEM

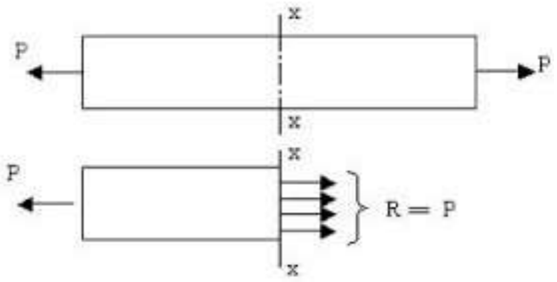
UNIT 1 – STRESS AND STRAIN

Topic 1: – STRESS AND STRAIN AT A POINT

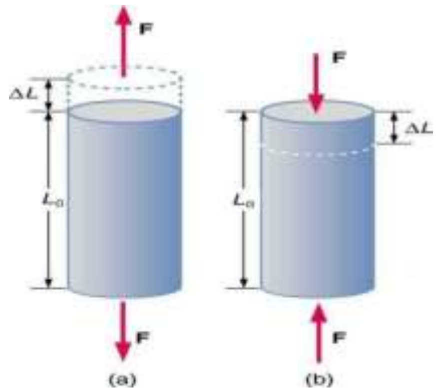
INTRODUCTION TO STRESS AND STRAIN

Definition

Stress: The internal resistance experienced by a material to deformation.



Strain: The measure of the amount of deformation that occurs in a material under stress. The ratio of change in dimension of the body to the original dimension.

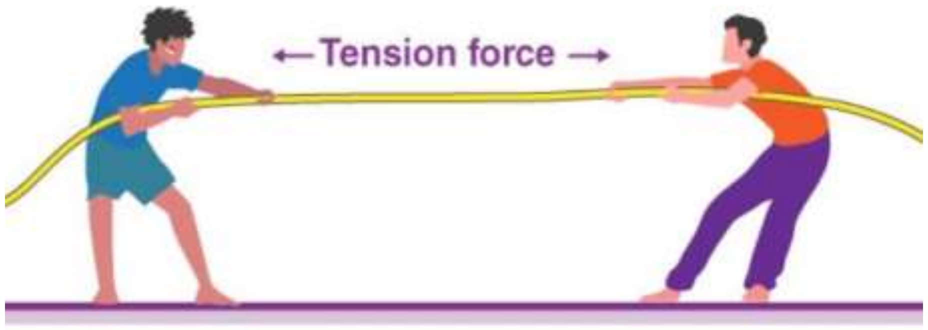


Types of Strain:
Longitudinal Stain= $\delta L/L$, Ratio of axial deformation to the original length of the body
Lateral Starin= $\delta b/b \ or \ \delta d/d$

Different Types of Stress

Tension Stress:

Tension stress occurs when forces act outwardly on an object, trying to elongate it. Ex: Rope under tension & a stretched rubber band.

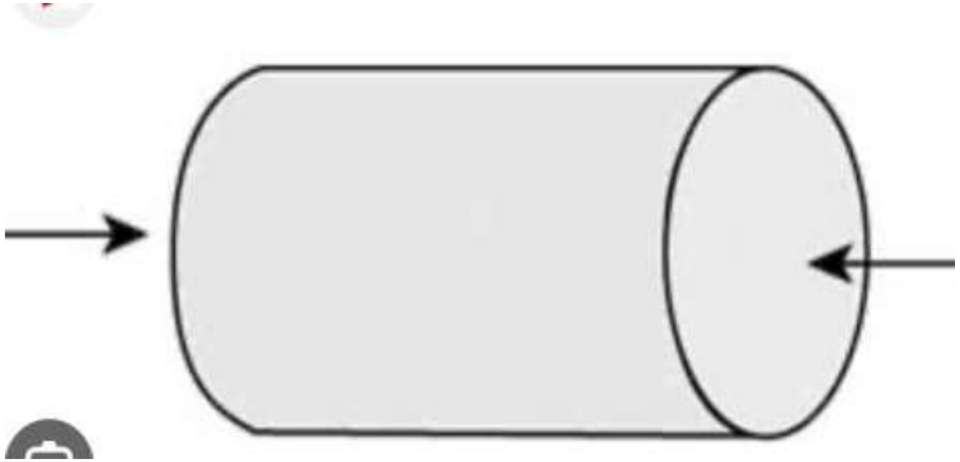


formula for tension stress: Stress (σ) = Force (P) / Cross-sectional area (A).

Compression Stress

Compression stress occurs when forces act inwardly on an object, trying to shorten or compress it.

Ex:-
A column supporting a structure or a book under the weight of other books.

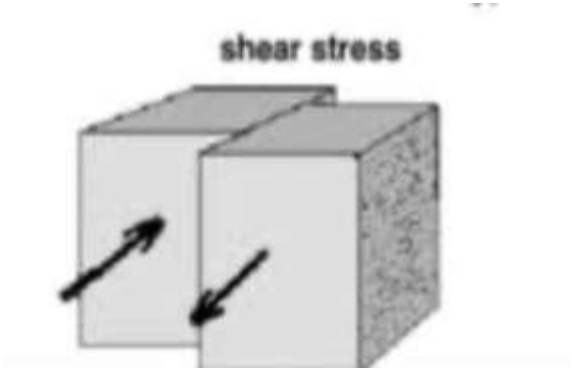


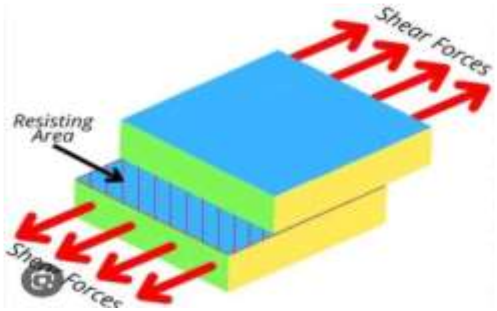
Formula for compression stress:

Stress (σ) = Force (P) /Cross-sectional area (A).

Shear Stress

Shear stress occurs when forces act parallel to the surface of an object, causing different layers of the material to slide past each other.
Ex:-
cutting a piece of paper with scissors or the movement of tectonic plates in the Earth's crust.



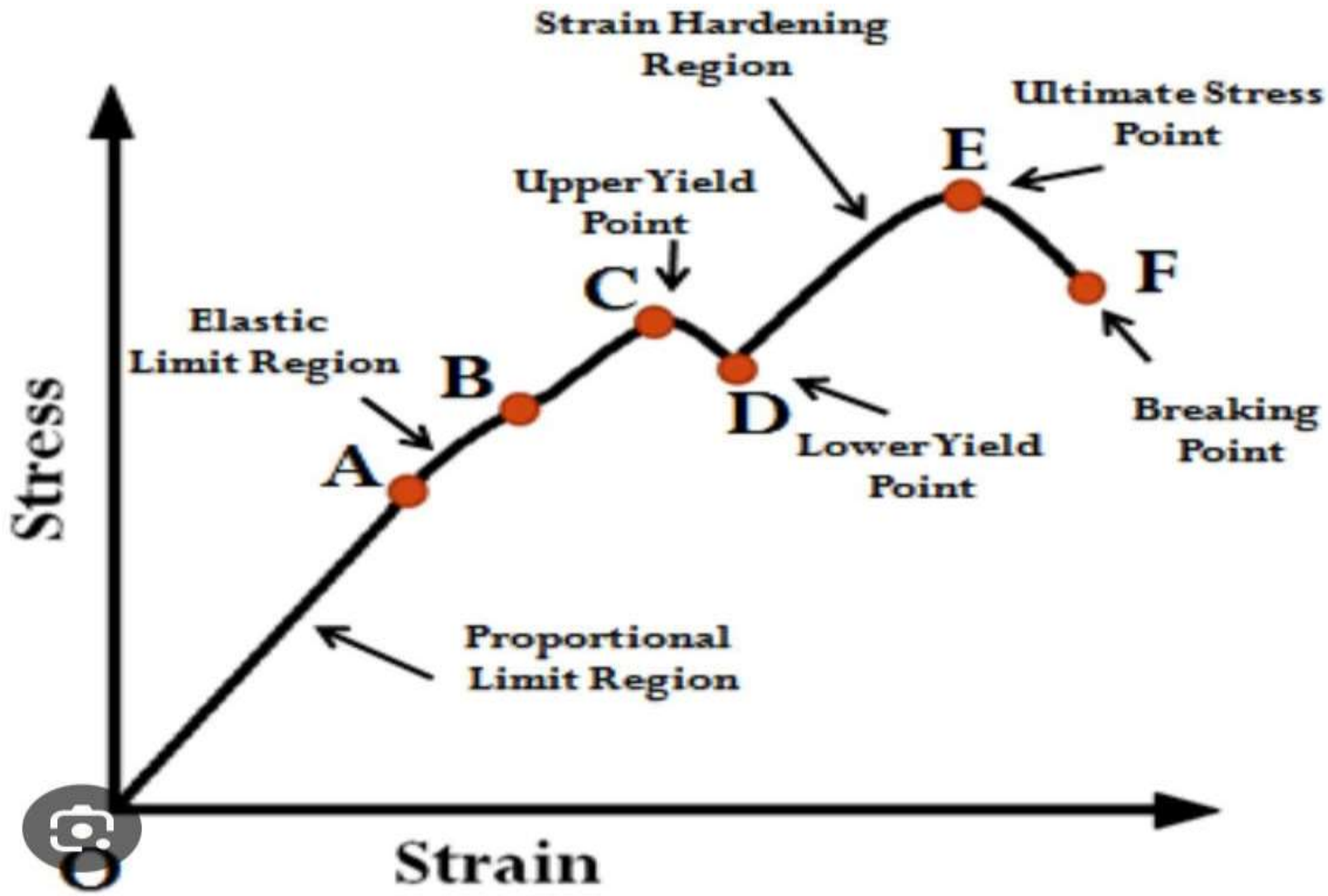


Shear Stress (τ) = Shear Force or Shear Resistance (R) / Area of the face or Shear Area (A).

Shear Strain (Φ) = Transversal displacement(dl)/ Height or thickness (h)

Other Stresses are:
Torsion,
Bending and
Fatigue.

Stress-Strain Curve



Elastic Region

- The initial portion of the curve is known as the elastic region. In this region, the material exhibits a linear relationship between stress and strain, following **Hooke's Law**.

According to Hooke's Law, stress (σ) is directly proportional to strain (ε) within the elastic limit of the material.

Stress ∝ Strain

$$\sigma \propto \varepsilon$$

$$\sigma = E\varepsilon$$

$$E = \frac{\sigma}{\varepsilon}$$

$*E$ = Young's modulus of elasticity

- When a material is subjected to a small amount of stress within this region, it undergoes deformation but can return to its original shape when the stress is removed. The material behaves like a spring, storing elastic potential energy. The slope of the curve in the elastic region represents the material's stiffness, and this slope is governed by a material property known as Young's Modulus (E).

Yield Point

- The yield point is the stress value beyond which the material undergoes permanent deformation, even if the applied stress is removed. Once the material has surpassed its yield point, it enters the plastic deformation region.

- Not all materials exhibit a well-defined yield point. Some materials, like ductile metals, show a yield plateau, indicating a range of stress where plastic deformation occurs without a significant increase in stress.

Plastic Deformation Region

- In this region, the material experiences significant plastic (permanent) deformation with relatively constant or slightly increasing stress. The strain continues to increase even if the applied stress remains constant.
- The material is now permanently deformed, and its ability to return to its original shape is reduced or lost entirely. The material will not behave elastically anymore.

Ultimate Tensile Strength (UTS)

The ultimate tensile strength is the highest point on the stress-strain curve, representing the maximum stress the material can withstand before failure (fracture) occurs. It is a critical property for materials that experience tension forces.

Fracture Point

The fracture point is the stress value at which the material fails, resulting in complete separation or rupture. At this point, the material can no longer support any additional stress, and it breaks into two or more pieces.

CONCLUSION

- The stress-strain curve provides valuable information about a material's mechanical behavior, including its strength, stiffness, ductility, and brittleness. Different materials will have different stress-strain curves based on their inherent properties and microstructure.

- By analyzing the stress-strain curve, engineers and material scientists can make informed decisions about material selection, design structures with appropriate safety margins, and predict how materials will behave under different loading conditions, ensuring the overall safety and reliability of engineering applications.

- Young’s Modulus or Modulus of Elasticity:

The ratio of stress to the corresponding strain is a constatnt. this ratio is called Young’s modulus(E).

$$E=\sigma / e$$

- Modulus of Rigidity or Shear Modulus:

The ratio of shear stress to the corresponding shear strain within the elastic limit is known as Modulus of Rogidity or Shear Modulus. Denoted by

C por G or N= Shear Stress/Shear Strain

$$G = \tau/\emptyset$$

- Factor of Safety:

Ratio of ultimate Stress to the working (permissible) stress

FOS= Ult Stress/ Permissible stress

Poisson’s Ratio(μ):

Ratio of lateral strain to the longitudinal strain is a constant for given material, within elastic limit. The ratio is called Poisson’s ratio

$$\mu = \ Lateral\ Strain/\ Longitudinal\ strain$$

Relationship among Elastic Constants:

- Relation B/w Young's modulus abd shear modulus (G) is

$$E = 2G(1 + \mu)$$

- Relation B/w Young's Modulus and Bulk Modulus(K) is

$$E = 3K(1 - 2\mu)$$

- Relation on all three Elastic Constants:

$$E = \frac{9KG}{G+3K}$$

Equations:

$$STRESS\ \sigma = P/A$$

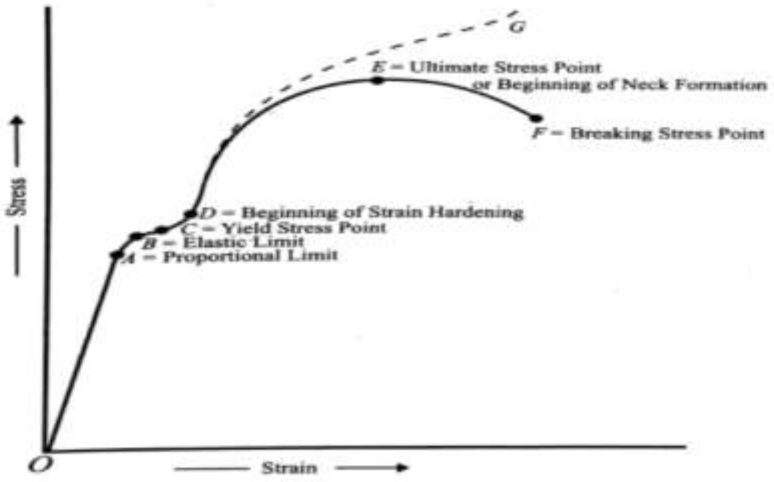
$$STRAIN\ e = \delta L/L$$

$$Hooke's\ law \quad STRESS\ \sigma = E * e$$

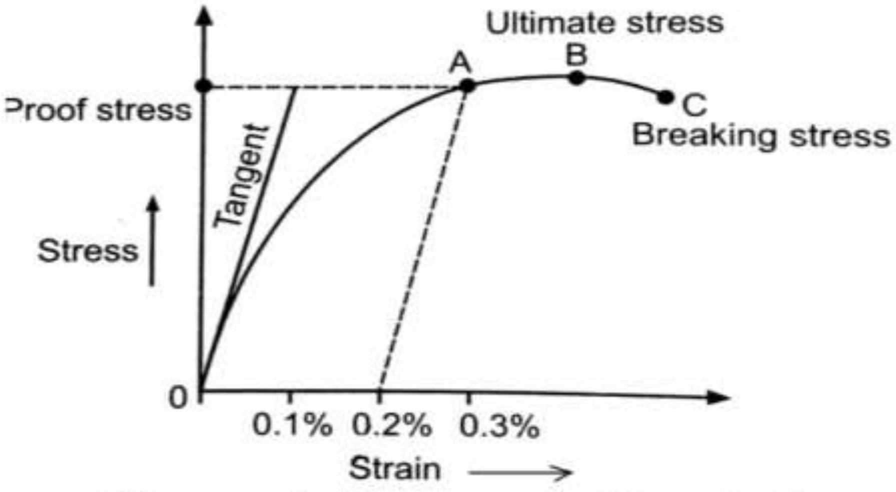
$$STRAIN\ e = P/AE$$

$$CHANGE\ IN\ LENGTH\ \delta L = PL/AE$$

Stress Starin Curve for Mild Steel and TOR Steel:



Stress- strain curve for Mild steel



Stress- strain curve for Tor steel

Stress Strain for Concrete

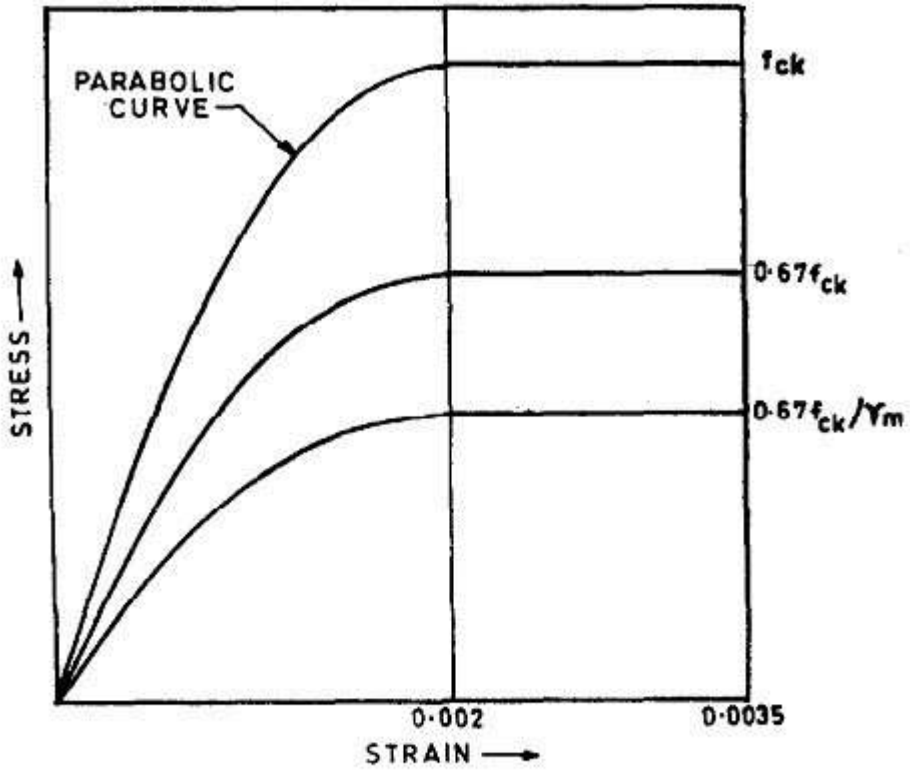


Fig. 21 Stress-Strain Curve for Concrete

Factor of Safety:

Ratio of Ultimate Stress to the Working Stress

$$\mu = \frac{\text{Ultimate Stress}}{\text{Permissible Stress}}$$

Shear Modulus:

$$\text{C or G or N} = \frac{\mathit{Shear\ Stress}}{\text{Shear Strain}}$$

Bulk Modulus:

$$K = \frac{\mathit{Direct\ stress}}{\text{Volumetric Strain}}$$

Thermal Stress:

Stress induced in abody due to change in temperature.

*Extension in rod due to thermal stress:

$$\partial L = \alpha T L$$

$\alpha = coefficient\ of\ linear\ expansion$

T= rise in temperature

L= Length of the object

* Thermal Stress, $\sigma = \alpha T E$

* Thermal Strain, e= $\dfrac{\alpha T L - \delta}{L}$

* Thermal Stress, $\sigma = \dfrac{\alpha T L - \delta}{L} * E$

Volumetric Strain:

Ratio of change in volume to the original volume of a body.

$$e_v = dV/V$$

$$e_v = dL\ (1-2\mu) / L$$

Principal Planes:

The planes which have no shear stress are known as Principal Planes.

Principal planes are the planes of zero shear stress. The planes carry only normal stresses.

Normal Stress acting on a principal plane is called principal stresses.

Mohr’s Circle:

Mohr's Circle for strain is the circle in which every point represents the value of Normal strain and Shear strain for a plane of a body having a two-dimensional strain. Mohr's Circle of strain can be used for finding the normal strain and shear strain of a body on a plane.

THANKYOU