SIMPLE STRESS & STRAIN

Chapter-6

INTRODUCTION

- When an external force acts on a body, the body tends to undergo some deformation.
- Due to cohesion between the molecules, the body resists deformation.
- This resistance by which material of the body opposes the deformation is known as "strength of material".
- Strength of material or mechanics of material involves analytical methods for determining the strength, stiffness and stability of various load carrying members.

TYPES OF LOADS

- Dead loads - static in nature, such as the self-weight of the roof.
- Live loads - fluctuating in nature, do not remain constant- such as a weight of a vehicle moving on a bridge.
- Tensile loads - applied force has pulling effect on the body.
- Compressive loads - applied load has pushing effect towards a point.
- Shearing loads - applied load is parallel or tangent to the surface.

PROPERTIES OF MATERIAL

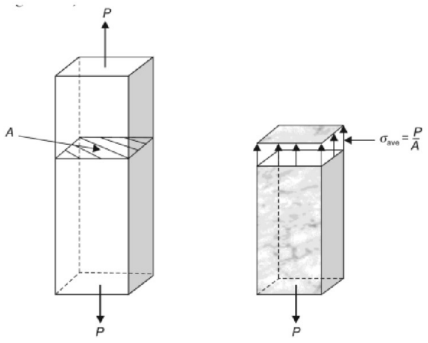
- Elasticity – Deformation disappears on removal of load.
- Plasticity – Does not regain its original dimensions on removal of loading.
- Brittleness – Does not undergo any deformation when subjected to an external loading.
- Malleability – Materials ability to be hammered out into thin sheets, such as lead.
- Ductility – Exhibit relatively small extensions to fracture such as glass and cast iron.

STRESS

- Stress is an internal resistance offered by a unit area of the material, from which a member is made, to an externally applied load.
- The resistance of material or the internal force acting on a unit area may act in any direction.

STRESS

- $\sigma = \dfrac{\textit{Applied Load}}{\textit{Original cross-Sectional Area}}$
- $\sigma = \dfrac{P}{A}$
- unit of stress is N/m^2



TYPES OF STRESS

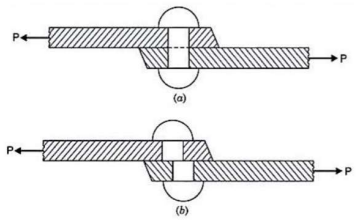
- Tensile Stress
  - The stress induced in a body, when subjected to two equal and opposite pulls, as a result of which there is an increase in length, is known as *"tensile stress"*.
  - The ratio of increase in length to the original length is known as *"tensile strain"*.
  - $\sigma = \frac{Tensile\ Load}{Area} = \frac{P}{A}$
  - $e = \frac{Increase\ in\ length}{original\ length} = \frac{dL}{L}$

TYPES OF STRESS

- Compressive Stress
  - The stress induced in a body, when subjected to two equal and opposite pushes, as a result of which there is decrease in length, is known as *"compressive stress"*.
  - The ratio of decrease in length to the original length is known as *"compressive strain"*.
  - $\sigma = \frac{Push}{Area} = \frac{P}{A}$
  - $e = \frac{Decrease\ in\ length}{original\ length} = \frac{dL}{L}$

TYPES OF STRESS

- Shear Stress (τ)
  - The stress induced in a body, when subjected to two equal and opposite forces which are acting tangentially across the resisting section, as a result of which the body tends to shear off across the section, is known as *"shear stress".*
  - The corresponding strain is known as *"shear strain".*



ELASTICITY & ELASTIC LIMIT

- *When an external force acts on a body, the body tends to undergo some deformation. If the external force is removed and the body comes back to its original shape and size, the body is known as elastic body.*
- *This property, by virtue of which certain materials return back to their original position after the removal of the external force, is called elasticity.*
- *Limiting value of force up to which, the deformation completely disappears on the removal of the force.*
- *The value of stress corresponding to this limiting force is known as the elastic limit of the material.*

HOOK'S LAW

- When the material is loaded within its elastic limit, the stress is proportional to strain.

$$\sigma \alpha e$$

$$\sigma = Ee$$

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

- This proportionality constant is known as young's modulus or modulus of elasticity (E).
- Modulus of rigidity (G) or shear modulus is the ratio of shear stress to shear strain.

Poisson's Ratio: The ratio of lateral strain to the longitudinal strain is a constant for a given material, when the material is stressed within the elastic limit.

$$Poisson's\ Ratio, \square = \frac{Lateral\ Strain}{Longitudinal\ Strain}$$

The strain at right angles to the direction of applied load is known as *lateral strain.*

The *longitudinal strain* is defined as the deformation of the body per unit length in the direction of the applied load.

STRESS – STRAIN RELATIONSHIP

- Properties of materials used for engineering applications can be determined by conducting laboratory tests on small specimens of the material.
- Tension test involves application of gradually increasing axial tensile load on a standard specimen.
- The test is performed on Universal testing Machine (UTM).
- The results of the test are plotted on graph, with strain on x-axis and stress on y-axis.
- The stress-strain diagram help in conveying information about mechanical properties and behaviour of the material.

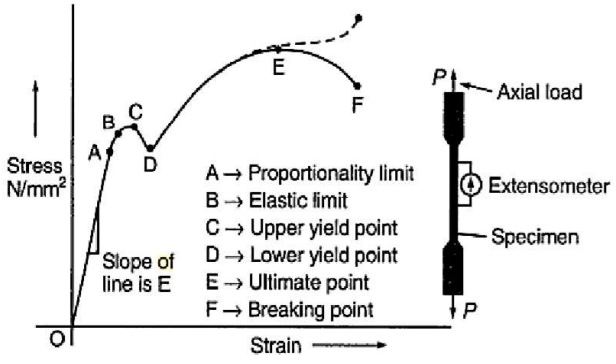
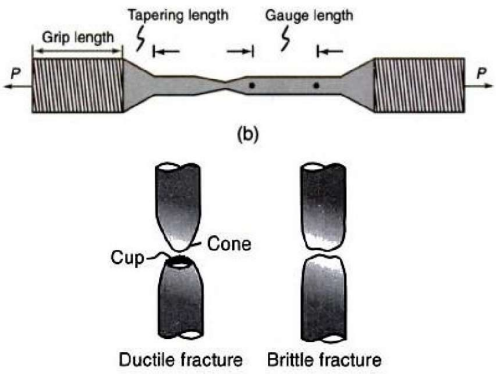


Figure: Stress-strain curve for structural steel



Ultimate Strength: It is the highest point on the stress-strain diagram. It is defined as the ratio of maximum load to the original cross-sectional area.

$$Ultimate\ strength = \frac{Maximum\ Load}{Original\ cross-sec\ area}$$

Working Stress: It is defined as the ratio of ultimate strength to the factor of safety.

For structural streel, FOS is taken as 2 to 2.5. For brittle material, it is taken as 4 to 6.