Simple Stresses and Strains

Prepared By
SANJAY KUMAR
Assistant Professor
Department of Mechanical Engineering
YMCA University of Science & Technology, Faridabad
Objectives

- To classify stress into different categories.
- To know the statement and application of Hooke’s law.
- To calculate stress intensities caused by the applied loads in simple and composite sections.
- To calculate stresses and strains due to change of temperature.
- To state and derive the relations between various elastic constants.
Objectives (Contd...)

- To understand the behaviour of materials under compression and tension.
- To get the concept of strain energy.
- To calculate the strain energy due to normal stresses for gradually applied, suddenly applied and impact loads.
- To calculate the elastic strain energy due to torsion.
- To calculate strain energy due to bending stress and shear stress.
Basic Concepts

• The resistance to deformation per unit area of a body is known as **stress** and the ratio of deformation to the original length is called **strain**.

So, stress, \( f = \)

strain, \( e = \)

where
- \( A \) = Cross-sectional area
- \( P \) = Force on the body
- \( f \) = Stress on the body
- \( L \) = Original length
- \( \delta L \) = Deformation in length
Basic Concepts (Contd…)

• When a body is subjected to two equal and opposite pulls so that the body lends to elongate, the stress induced in the body is known as tensile stress and the corresponding strain is known as tensile strain.

• When a body is subjected to two equal and opposite pushes so that the body tends to shortened, the stress induced in the body is known as compressive stress and the corresponding strain is known as compressive strain.
Basic Concepts *(Contd...)*

• The limiting value of the stress upto which if the material is stressed and then released, strain disappears completely and the original length and the shape are regained is known as **elastic limit**.

• Hooke’s law states that whenever a material is loaded within the elastic limit, the stress is proportional to the strain.

• The axial stress produced due to unit axial strain within the elastic limit is known as **Young’s modulus** or modulus of elasticity.

\[ f \propto e \quad \text{or,} \quad E = f/e \]

where \( E = \text{Young’s modulus} \).
- For a bar of uniform cross-section
  
  Deformation $\delta L =$

- For a bar of varying cross-section
  
  $\delta L =$ + ......

- For circular bar with diameter varying uniformly from $d_1$ to $d_2$
  
  $\delta L =$

- Free expansion of a bar due to change in temperature is
  
  $\delta L = \alpha t L$. 
For a compound bar force developed due to change in temperature is same in both materials. However, the force developed in the bar with higher value of coefficient of thermal expansion is compressive and in another it is tensile.

\[ = (\alpha_1 - \alpha_2) \ tL \]

where \( \alpha_1 > \alpha_2 \).
Poisson’s Ratio

- Within elastic limit, the ratio of lateral strain to the longitudinal strain is known as Poisson’s ratio and is denoted by $\mu$ or $\nu$.

- The ratio of change in value of a body to its original value is known as volumetric strain.

- Volumetric strain of a rectangular cylindrical body subjected to an axial load $p$, is given by

$$ev = e$$

- Within the elastic limit, the ratio of normal stress to the corresponding volumetric strain is known as Bulk modulus and is denoted by $K$.

(Contd...)
Relation

- Within elastic limit, the ratio of shear stress to the shear strain is known as modulus of rigidity and is denoted by $G$.
- Relation between Young’s modulus $E$ and Bulk modulus $K$ is given by
  $$ E = 3K (1 - 2 \mu) $$
- Relation between modulus of rigidity $G$ and Young’s modulus $E$ is given by
  $$ E = 2G (1 + \mu). $$
- Strain energy due to direct stress = $\frac{1}{2} \times v$. 

- Strain energy due to shear stress = $\frac{1}{2} q G \times v$. 
Stress induced due to various loads are obtained by equating strain energy to external energy. Stress due to

(a) Gradually applied loads $p =$

(b) Suddenly applied loads $p =$

(c) Impact load falling from a height $h$

$$ p = $$

(d) Shock $U$; $p =$