Stresses and Strain (Simple and Principal)

Concept of elasticity and plasticity

- **Strength** of Material is its ability to withstand and applied load without failure.
- **Elasticity**: Property of material by which it return to its original shape and size after removing the applied load , is called elasticity. And material itself is said to elastic.
- Plasticity: Characteristics of material by which it undergoes inelastic strains (Permanent Deformation) beyond the elastic limit, known as **plasticity**. This property is useful for pressing and forging.

Direct or Normal Stress

When a force is transmitted through a body, the body tends to change its shape or deform. The body is said to be strained.

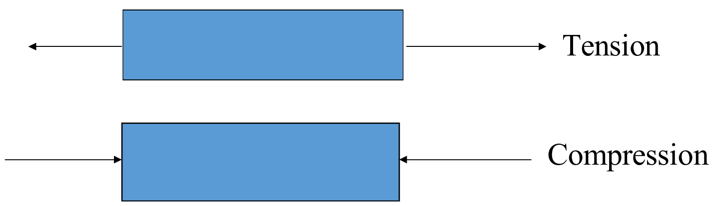
Direct Stress = $\dfrac{\text{Applied Force (F)}}{\text{Cross Sectional Area (A)}}$

Units: Usually N/m^2 (Pa), N/mm^2, MN/m^2, GN/m^2 or N/cm^2

Note: $1\ N/mm^2 = 1\ MN/m^2 = 1$ MPa

Direct Stress Contd.

- Direct stress may be tensile or compressive and result from forces acting perpendicular to the plane of the cross-section



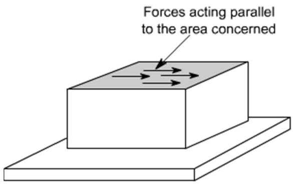
Direct or Normal Strain Contd.

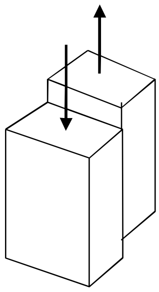
- As strain is a ratio of lengths, it is dimensionless.
- Similarly, for compression by amount, dl: Compressive strain = - dl/L

Note: Strain is positive for an increase in dimension and negative for a reduction in dimension.

Shear Stress and Shear Strain

- Shear stresses are produced by equal and opposite parallel forces not in line.
- The forces tend to make one part of the material slide over the other part.
- Shear stress is tangential to the area over which it acts.





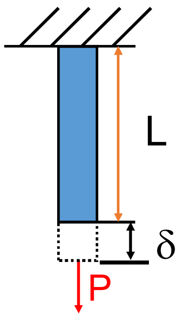
Strain

•It is defined as deformation per unit length

• it is the ratio of change in length to original

•Tensile strain (+ Ve) (ε) $= \dfrac{\text{increase in length}}{\text{Original length}} = \dfrac{\delta}{L}$

Compressive strain (- Ve) (ε) $= \dfrac{\text{decrease in length}}{\text{Original length}} = \delta$



Ultimate Strength

The strength of a material is a measure of the stress that it can take when in use. The ultimate strength is the measured stress at failure but this is not normally used for design because safety factors are required. The normal way to define a safety factor is :

$$safety\ factor = \frac{stress\ at\ failure}{stress\ when\ loaded} = \frac{Ultimate\ stress}{Permissible\ stress}$$

Strain

We must also define **strain**. In engineering this is not a measure of force but is a measure of the deformation produced by the influence of stress. For tensile and compressive loads:

Strain is dimensionless, i.e. it is not measured in metres, kilograms etc.

$$strain \quad \varepsilon = \frac{increase\ in\ length\ \ x}{original\ length\ \ L}$$

For shear loads the strain is defined as the angle γ This is measured in radians

$$shear\ strain \quad \gamma \approx \frac{shear\ displacement\ \ x}{width\ \ L}$$