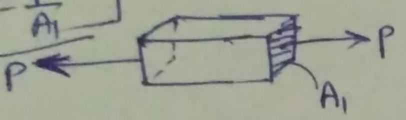
Types of stress -

Stress

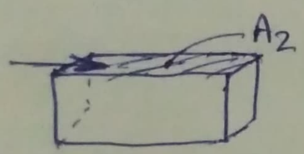
- Normal stress
  - Tensile stress
  - Compressive stress
- Shear stress

Normal stress → when a force is applied perpendicular to a surface it produces Normal stress on the surface.

$$\boxed{\sigma = \frac{P}{A_1}}$$

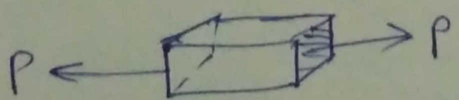


Shear stress → when a force is applied parallel to the surface it produces shear stress on the surface.



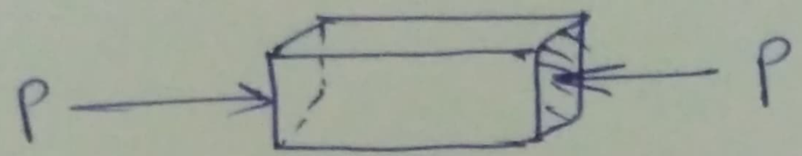
$$\boxed{\text{shear stress } (\tau) = \frac{P}{A_2}}$$

Tensile stress → it is a type of Normal stress which is induced due to a force applied normal to a surface such that, it tends to increase the length of the body.



$$\text{Tensile stress } (\sigma_t) = \frac{P}{A}$$

Compressive stress → it is a type of Normal stress which is induced due to a force applied normal to a surface, such that it tends to reduce the length of the body.



$$\boxed{\text{Compressive stress } (\sigma_c) = \frac{P}{A}}$$

UNIT ①

Stress ⇒

when an external force acts on a body, the body tends to undergo some deformation. But due to cohesive force betn the molecules, the body resists deformation. this resisting force per unit area is called stress or intensity of stress.

Mathematically -

$$\text{Stress}\ (\sigma) = \frac{\text{Load}\ (P)}{\text{Area}\ (A)}$$ in N/m^2 or N/mm^2

$\begin{cases} \text{tensile stress} = \dfrac{\text{tensile load}}{\text{Area}} \\ \text{compressive stress} = \dfrac{\text{comp. load}}{\text{Area}} \end{cases}$

Strain ⇒

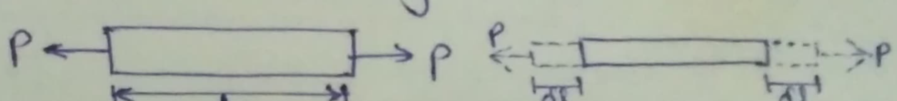
when a body is subjected to some external force, there is some change of dimension of the body. the ratio of change of dimension of the body to the original dimension is known as strain. strain is dimensionless.

or ⇒ when a body is acted upon by tensile or compressive loading, its dimensions will increase or decrease along line of action of load applied. this deformation (change in length) per unit original length is called longitudinal strain or primary strain.

longitudinal strain

$$\text{strain}\ (\varepsilon) = \frac{\text{change in length}}{\text{original length}} \qquad \boxed{\varepsilon = \frac{\delta l}{l}}$$

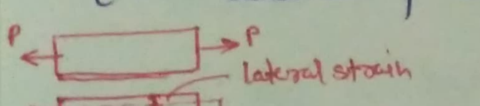
⇒ it is taken positive if there is extension of the bar, and it is taken negative if there is shortening in bar.



** Poisson's Ratio ⇒

As we know that; strain in the direction of applied load is called longitudinal or primary strain and the strain in perpendicular (transverse) direction is called lateral or secondary strain.

Lateral strain



$$\text{longitudinal strain} = \frac{\delta l}{l}$$

$$\text{Lateral strain} = \frac{\delta d}{d} \quad \text{or} \quad \frac{\delta t}{t}$$

⇒ when the deformation of the bar is within elastic limit, the ratio of the lateral strain to the longitudinal strain is const. for a given material. this ratio is called poisson's ratio and it is denoted by (μ).

⇒ the value of μ lies betn 0.25 and 0.33 for most of the engg. Materials.

Poisson's Ratio

$$\boxed{\text{Poisson's Ratio} = \frac{\text{Lateral strain}}{\text{longitudinal strain}}} \qquad \boxed{\mu = \frac{\delta d/d}{\delta l/l}}$$

✓

** Hook's law →

Hook's law states that, when a material is loaded within elastic Limit, stress is directly proportional to strain.

Mathematically -

$$\text{stress} \propto \text{strain}$$

$$\sigma \propto \varepsilon$$

or

$$\sigma = \text{Const. of proportionality} \times \text{strain}$$

$$\sigma = E \times \varepsilon$$

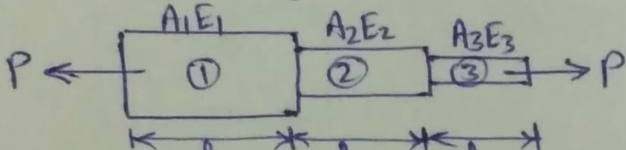
or $\boxed{E = \dfrac{\sigma}{\varepsilon}}$ { unit. N/m^2 or N/mm^2

where 'E' is called young's Modulus or Modulus of Elasticity.

** Principle of superposition →

the total elongation in any stepped bar due to a load is the algebraic sum of elongations in individual parts of the bar.

Exp- if.



if δl_1 = elongation in ①
δl_2 = elongation in ②
δl_3 = elongation in ③

then - $\boxed{\text{total } (\delta l) = \delta l_1 + \delta l_2 + \delta l_3}$

Or → if a ~~mk~~ member is subjected to a number of forces on its outer edges (ends) as well as at some intermediate sections along its length. the force are then split up and their effects are considered on individual sections. the resulting deformation is then given by the algebraic sum of the the deformation of the individual sections. this is principle of superposition.

As we know that

$$\sigma = \frac{P}{A}, \quad \varepsilon = \frac{\delta l}{l}$$

And $E = \dfrac{\sigma}{\varepsilon} = \dfrac{P/A}{\delta l/l}$ Put the value

or $E = \dfrac{Pl}{A \cdot \delta l}$

or $\boxed{\delta l = \dfrac{Pl}{AE}}$

Remember it.

Some important formulae

Relation betn E, K & G

E = young's Modulus (Modulus of Elasticity)

K = Bulk Modulus

G = Modulus of Rigidity

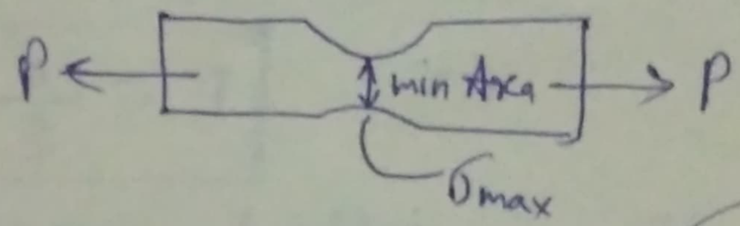
$\boxed{E = 3K(1-2\mu)}$

$\boxed{E = 2G(1+\mu)}$

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

Hook's Law Assumption →

* chemical composition is Const. throught. the body
* there is no change in tempr during loading (Const. tempr.)
* there is no stress concentration & the surface is perfectly smooth
* the material is deformable.

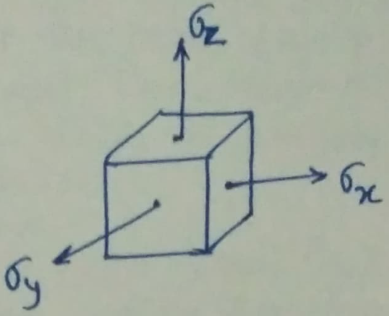


$$\because \sigma = \frac{P}{Area}$$

* Volumetric stress →

it is the average of stresses acting along the three mutually perpendicular directions.

$$\boxed{\sigma_v = \frac{\sigma_x + \sigma_y + \sigma_z}{3}}$$



* Volumetric strain is defined as change in volume of body per unit original volume.

$$\boxed{\varepsilon_v = \frac{\delta V}{V}}$$

⇒ Hook's law states that within elastic limit all stress are directly proportional to their respective strain (corresponding strain)

* for Normal stress - $\sigma \propto \varepsilon \Rightarrow \sigma = E\varepsilon$ or $\boxed{E = \frac{\sigma}{\varepsilon}}$

  Modulus of Elasticity

* for shear stress - $\tau \propto \phi \Rightarrow \tau = G\phi$ or $\boxed{G = \frac{\tau}{\phi}}$

  Modulus of Rigidity

* for volumetric stress - $\sigma_v \propto \varepsilon_v \Rightarrow \sigma_v = K\varepsilon_v$ or $\boxed{K = \frac{\sigma_v}{\varepsilon_v}}$

  Bulk Modulus of elasticity

* Relationship betn Elastic Constant (E, K, G)

① $\boxed{E = 2G(1+\mu)}$

② $\boxed{E = 3K(1-2\mu)}$

③ $\boxed{E = \frac{9KG}{3K+G}}$

Note -
Modulus of Rigidity is denoted by letter C or G

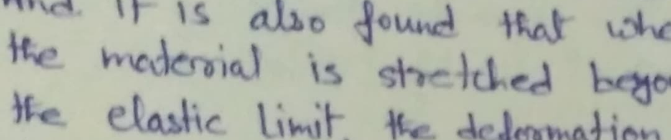
Stress strain Diagram →

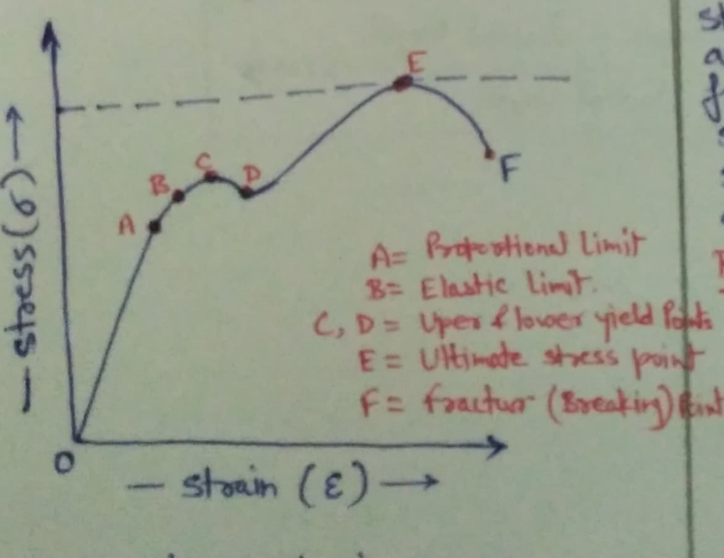
(for Mild steel, Ductile material)

Stress - strain curve is a graphical plot of stress - versus strain.

As we already know that whenever some external forces acts on a body, it undergoes some deformation. if a body is stressed within its elastic limit the deformation entirely disapears as soon as the forces are removed. And it is also found that when the material is stretched beyond the elastic limit, the deformation ~~is~~ does not disapear entirely, even after the removal of load and there remains some residual deformation.

⇒ we study this phenomenon, in a greater detail by reffering to a tensile test for a mild steel bar and all phenomenon is ploted ~~on~~ and represented by a diagram, or (Graphically represented) this diagram is known as stress-strain diagram.





stress - strain curve

Imp.

Take a speciman of mild steel bar of uniform c/s, Let this bar is subjected to gradually increasing pull. Now if plot the stress along the vertical Axis, and the corresponding strain along horizotal Axis and draw a curve, we shall obtain a graph as shown in fig.

Proportional Limit we can see from the graph, that the curve from point O to A is straight line, which represents that the stress is Linearly proportional to strain.

~~from~~

Elastic Limit → from Point A to B, the curve slightly deviates from the straight line but the material still shows elastic behaviour until the curve reaches to point B, which is called elastic limit. upto this point B if the load is removed the specimen will still come back to its original position. it is thus obious Hooke's law holds good only up to this limit.

yield Point → when the specimen is stressed beyond the elastic limit, the strain increases more quitly than the stress. this happens, because a sudden elongation of the specimen takes place without an appriciable increase in the stress (or load). this phenomenon is called yielding. After point B the material shows plastic behaviour.

Ultimate strength (or tensile strength) →

At point D the specimen regains some strength and higher values of stress are required for higher strains. from points D to E is the region of strain hardening. At point E, the stress attains its maximum value and is know as ultimate stress.

Breaking (or fracture) Point → After the specimen has reached the ultimate stress, a neck is formed which decrease the c/s area of the specimen from Point E to F is the region of necking. Now the stress neccesary to break away the specimen, is less than the ultimate stress. the stress corresponding to the Point F is known as Breaking stress.

FOS In engineering, a factor of safety (FOS), also known as safety factor (SF), expresses how much stronger a system is than it needs to be for an intended load.

$$\boxed{FOS = \frac{\text{Ultimate strength}}{\text{working stress}}}$$

or

FOS ⇒ it is the ratio of the ultimate strength of a member to the Actual working stress.

{working stress, or permissible stress or allowable stress.

strength ⇒ the maximum value of stress, which a material can withstand.

⇒ the difference betⁿ elastic limit and proportional limit is, elastic limit is the point at which there is no permanent deformation in a structure or the point at which the body regains its original shape, while the proportional limit is the point at which stress is directly proportional to the strain.

⇒ Proportionality limit :- it is the limit beyond which linear variation of steel ceases.
(up to this ~~stress~~ strain is linearly vary with stress)

Elastic limit :- it is the limit up to which a specimen regains its original shape & size on removal of applied load. up to this point, Hook's law is applicable.

⇒ Actually, elastic limit comes just after the proportionality limit in stress-strain curve but it is difficult to determine the two limits separately in elastic range near the yield point of steel.
So, elastic limit is assumed to coincide with proportionality limit.