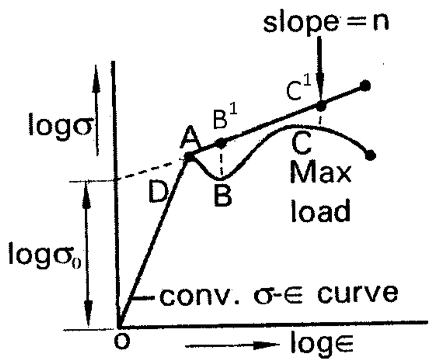
CONCEPT OF FLOW STRESS AND GENERALIZED HOOKE'S LAW

The stress required for plastic deformation or to make the metal flow to any given strain can be obtained from the true stress true strain curve. True stress true strain curve gives an idea about how the metal can flow plastically. Hence, it is referred to as "Flow Curve".



Flow Curve

Consider the stress strain curve for a metal from above the yield point ie., from the start of plastic flow to the maximum load at which the metal begins to form neck (BC). BC represent strain hardening region.

Taking log values of σ and ε for portion B to C, a stress strain curve can be plotted, which is a straight line B^1C^1.

If this straight line B^1C^1 is extended back, it will intercept the σ axis at D.

Let 'n' be the slope of the line B^1C^1which represents strain hardening portion BC of the stress strain curve. This slope n, is referred to as "strain hardening coefficient".

Let the straight line B^1C^1 cut the σ axis at the origin.

Let Log σ_0 be the intercept as shown in the figure.

Then $\log \sigma = \log \sigma_0 + n \log \varepsilon$ **is the equation for a straight line.**

ie., equation of the Stress at any point on the line.

$$\log \sigma = \log \sigma_0 + \log \varepsilon^n$$

$$\log \sigma = \log \sigma_0 \varepsilon^n$$

$$\text{or} \quad \sigma = \sigma_0 \varepsilon^n$$

This equation is referred to as "Flow Stress Equation".

Generalized Hooke's Law

Hooke's law in 1D states that Stress is proportional to strain within the proportionality limit.

$$\sigma \ \alpha \ \epsilon \quad \text{or} \quad \sigma = E\,\epsilon \quad \text{or} \quad \epsilon = \sigma/E$$

where E is constant of proportionality called as Young's Modulus or Modulus of Elasticity.

Consider a bar subjected to uniaxial tensile load. The length of the bar increases and the diameter decreases proportionately. Due to this there will be longitudinal strain along the length and lateral strain across the diameter of the bar. There exists a relation between these two types of strains which is referred to as "Poissons Ratio". It is defined as the ratio of Lateral strain to the longitudinal strain.

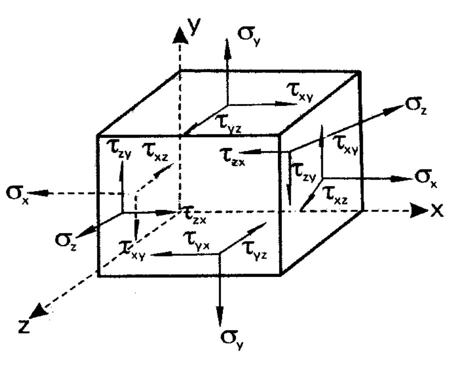
Poissons Ratio = (Lateral Strain/Longitudinal Strain)
(γ)

$$\gamma = \epsilon_{lat}/L_{ong}$$

In a 3D stress system there are 6 rectangular components of stresses σ_x σ_y σ_z

In a 3D stress system there are 6 rectangular components of stress ($\sigma_x\ \sigma_y\ \sigma_z\ \tau_{xy}\ \tau_{yz}\ \tau_{zx}$) and 6 rectangular component of strain. ($\in_x\ \in_y\ \in_z\ \gamma_{xy}\ \gamma_{yz}\ \gamma_{zx}$) respectively. Taking complimentary shear stresses to be equal

$$\tau_{xy} = \tau_{yz}$$
$$\tau_{yz} = \tau_{zy}$$
$$\tau_{zx} = \tau_{xz}$$



3^D Stress element

In matrix form it is written as

$$\sigma_{ij} \text{ or } \tau_{ij} = \begin{bmatrix} \sigma_x & \tau_{xy} & \tau_{xz} \\ \tau_{yx} & \sigma_y & \tau_{yz} \\ \tau_{zx} & \tau_{zy} & \sigma_z \end{bmatrix}$$