Strength of materials

Second Class

Al-Mustaqbal University

Asst.Lec.Ali Imad Al-Qizwini

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Strength of materials

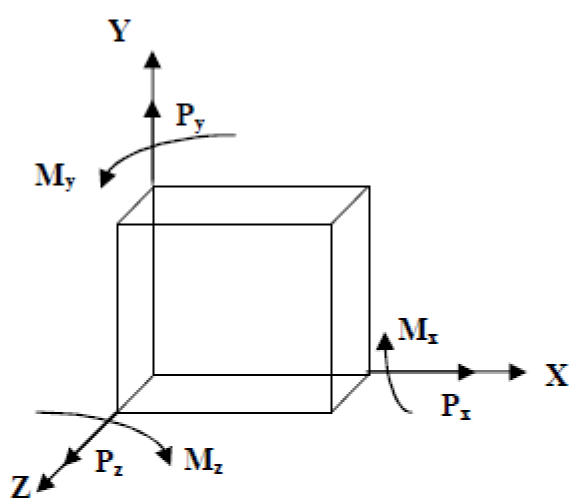
Chapter One

Simple Stresses

In any engineering structures or mechanism, the individual components will be subjected to external forces arising from the service condition or environment in which the component works. If the component or member is in equilibrium, the resultant of forces will be zero but nevertheless, they together place a load on the member which tends to deform that member and which must be reacted by internal forces which are set up within material.

Analysis of Internal Forces:
The most type of internal forces on any structure or member are:

1- Px: Axial force represents a tensile or compressive force in (X) direction.
2- Py, Pz: Shear force represents the resistance to sliding the portion to one side of the section past the other.
3- Mx: Torque represent to the resistance to twisting about X-axis.
4- My, Mz: Bending moment that measure the resistance to bending about (Y) or (Z) axis.



Types of Simple Stresses:

1) Normal stresses: (Tensile and Compressive Stresses)

One of the basic problems of the engineer is to select the proper material that is used in different applications like (structures or machines parts) to do most efficiently what it is designed to do. For this purpose, it is essential to determine the Strength, Stiffness and other properties of materials. The unit strength of materials is usually defined as the (Stress) in the material, and the stress expressed symbolically as:

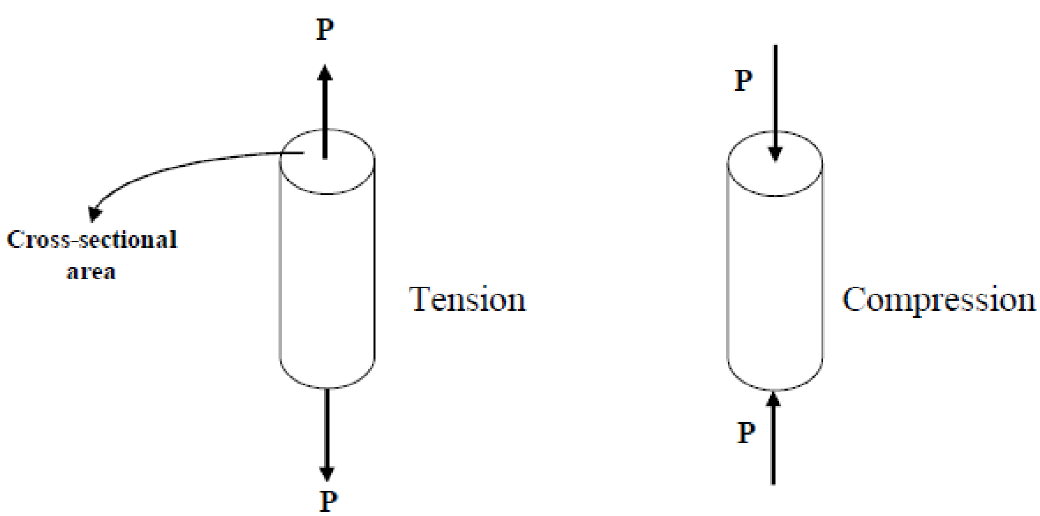
$$\sigma = \frac{P}{A_c}$$

where :

σ-------Stress (force per unit area) (N/m^2) or Pascal (Pa)

P-------Applied load (N)

A_C-----Cross-sectional area (m^2)



Axial tensile Force　　　Axial compressive force

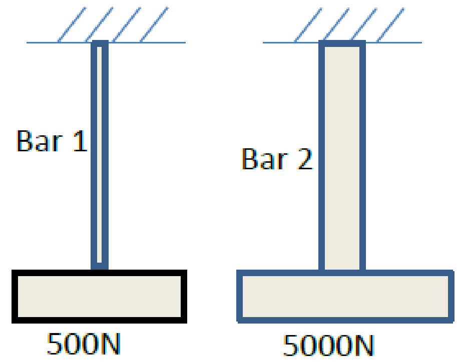
Units of stress

Pascal (Pa) = N/mm^2

MPa = MN/m^2 or equal to **N/mm^2**

GPa = GN/m^2 or equal to **kN/m^2**

Example : Which one of these two bars is stronger?

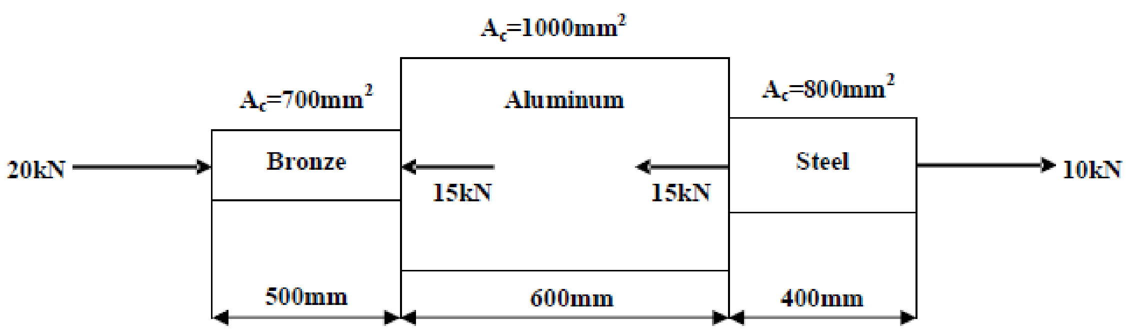


$$\sigma 1 = \frac{500\ N}{10\times10^{-6}} = 50\times10^{6}\ N/m^{2}$$

$$\sigma 2 = \frac{5000\ N}{1000\ \times10^{-6}\times m\text{^}2} = 5\times10^{6}\ N/m^{2}$$

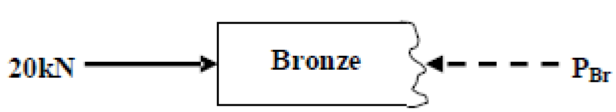
So The material of the bar 1 is ten times as stronger as material 2.

Ex: -1- An Aluminum rod is rigidly fastened between Bronze and Steel rods as shown in figure. Axial loads are applied at the position indicated Determine the stress in each rod.



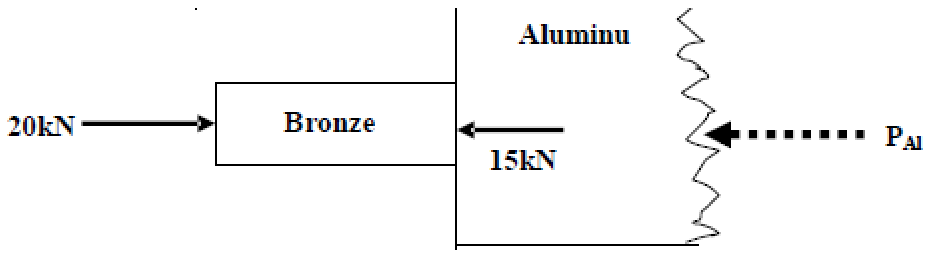
Sol: To calculate the stress in each rod , we first determine the total axial load in each rod .

1- For Bronze rod : By using the free-body diagram for Bronze rod



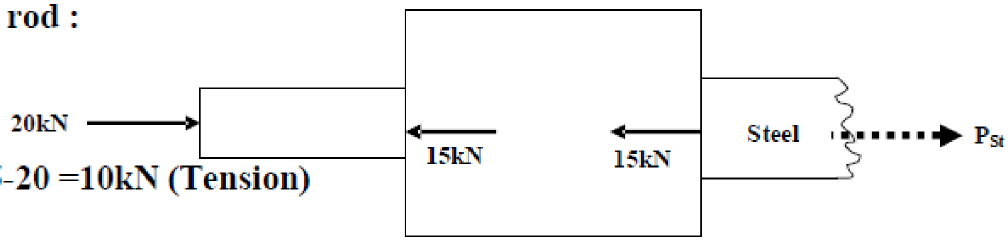
P_{Br}=20kN (Compressive)

2- For Aluminum rod :



P_{Al}=20-15 = 5kN (Compressive)

3- For Steel rod :



P_{St}=15+15-20 =10kN (Tension)

The stress in each rod now can be calculated :

$$\sigma_{Br} = \frac{P_{Br}}{A_{Br}} = \frac{20*10^3 (N)}{700*10^{-6} (m^2)} = 28.6*10^6 \frac{N}{m^2} = 28.6 MPa$$ **(Compressive stress)**

$$\sigma_{Al} = \frac{P_{Al}}{A_{Al}} = \frac{5*10^3 (N)}{1000*10^{-6} (m^2)} = 5 MPa$$ **(Compressive stress)**

$$\sigma_{St} = \frac{P_{St}}{A_{St}} = \frac{10*10^3 (N)}{800*10^{-6} (m^2)} = 12.5 MPa$$ **(Tensile stress)**

Ex: -2- Determine the largest weight (W) which can be supported by the two wires as shown in figure . The stresses in wires (AB) and (AC) are not to exceed (100MPa)and (150MPa) respectively . The cross-sectional area of the two wires are (400mm²) for wire (AB) and (200mm²) for wire (AC).

Sol:- First we must draw the free-body diagram

$\sum F_x = 0$ **(Equilibrium state)**

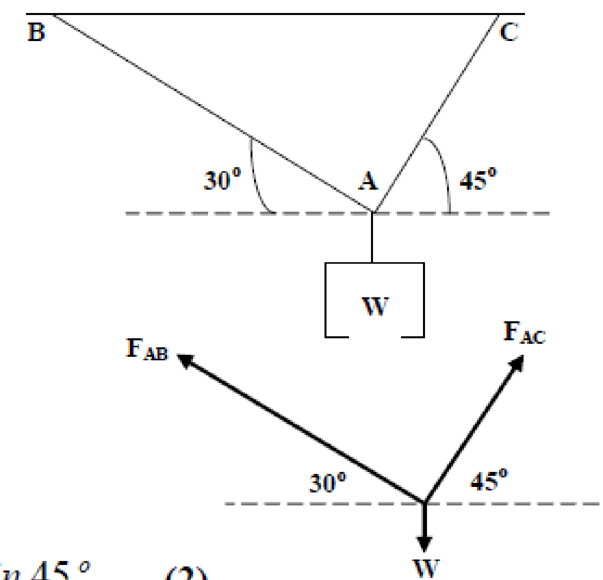
$$F_{AB} Cos\,30 = F_{AC} Cos\,45$$

$$F_{AB} = F_{AC} \frac{Cos\,45}{Cos\,30} = \frac{\frac{1}{\sqrt{2}}}{\frac{\sqrt{3}}{2}} = \frac{\sqrt{2}}{\sqrt{3}}$$

$$F_{AB} = \sqrt{\frac{2}{3}} F_{AC} \text{------(1)}$$

$$F_{AB} = 0.8165 F_{AC}$$

$$\sum F_y = 0 \longrightarrow W = F_{AB} Sin\,30^\circ + F_{Ac} Sin\,45^\circ \text{-----(2)}$$



Free-body diagram

Sub (1) in (2) :

$$W = 0.8165 F_{AC} Sin30^o + F_{AC} Sin45^o$$

$$\sigma = \frac{F}{A} \longrightarrow F_{AC} = \sigma_{AC} * A_{AC} = 150*10^6 * 200*10^{-6} = 30kN$$

$$W = 0.8165 * 30 * 10^3\, Sin\,30^o + 30 * 10^3\, Sin\,45^o$$

$$(W = 33.5kN)$$