Simple Stresses

Stress can be defined as the force per unit area, acting on small area (ΔA). It is a measure for intensity of a force.

* since there are different types of internal force, then there are several kinds of stresses, as follows:

A- Normal stresses: (Tensile and Compressive Stresses)

The force per unit area, acting normally on the small area. It is denoted by the Greek symbol (sigma(σ)).

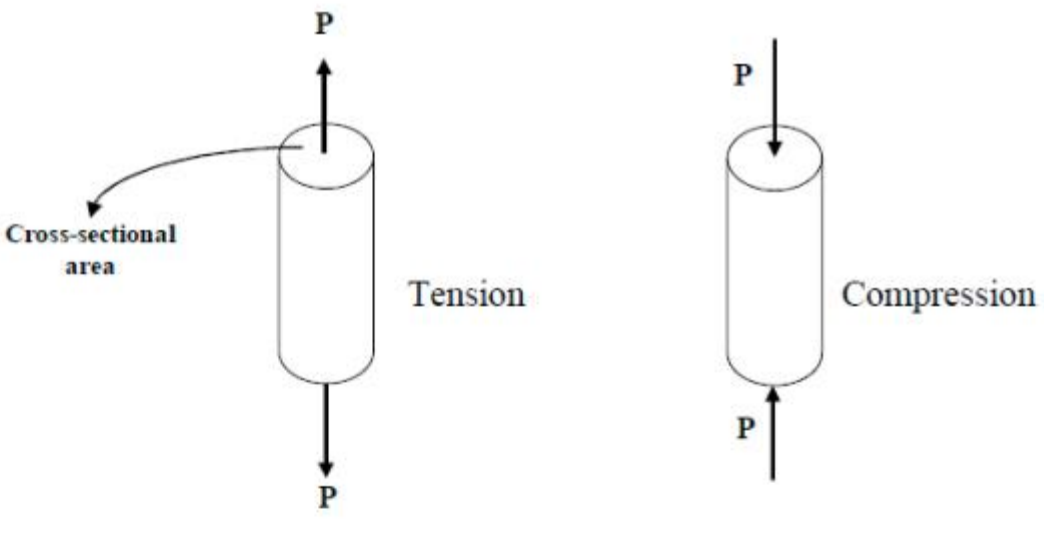
$$\sigma = \frac{P}{A_c}$$

where :

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

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

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

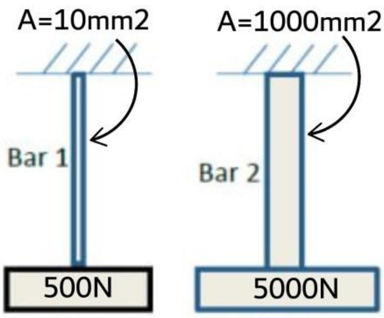


Axial tensile Force Axial compressive force

Units:

British units (FPS) (foot-pound-second)	Metric units	S.I. units International standard units
Force: Ib Kip= 1000 Ib Ton= 2204 Ib Ton= 2.204 kip	gm kg ton= 1000 kg	N KN= 1000 N Kg= 9.81 N ton= 9.81 kN
Area: in^2, ft^2	mm^2, cm^2, m^2	mm^2, cm^2, m^2
Stress: Ib/in^2=psi Ib/ft^2= psf Kip/in^2= ksi Kip/ft^2= ksf	g/cm^2 kg/cm^2 ton/m^2	N/m^2= passcal (Pa) kN/m^2= kilo passcal (kPa) N/mm^2= Mega passcal (MPa) (MPa= 10^6 Pa) Gega Pascal, GPa=10^9Pa

Ex1: which one of these two bars is stronger?

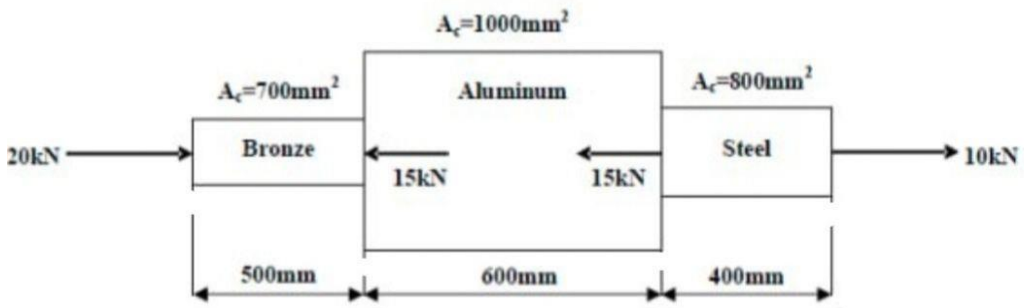


$$\sigma 1 = \frac{500}{10 * 10^{-6}} = 50 * 10^{6}\ N/m^{2}$$

$$\sigma 2 = \frac{5000}{1000 * 10^{-6}} = 5 * 10^{6}\ N/m^{2}$$

Bar1 **ten** times stronger than bar2

Ex2: 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.



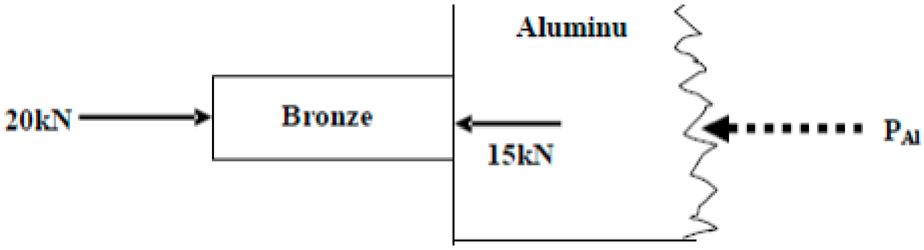
Sol:

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

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

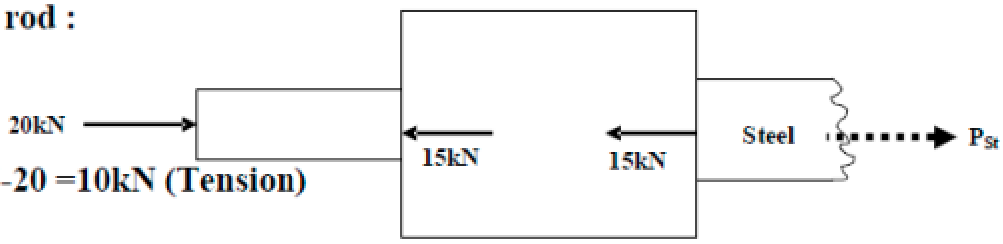
P_{Br}=20kN (Compressive)

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 :

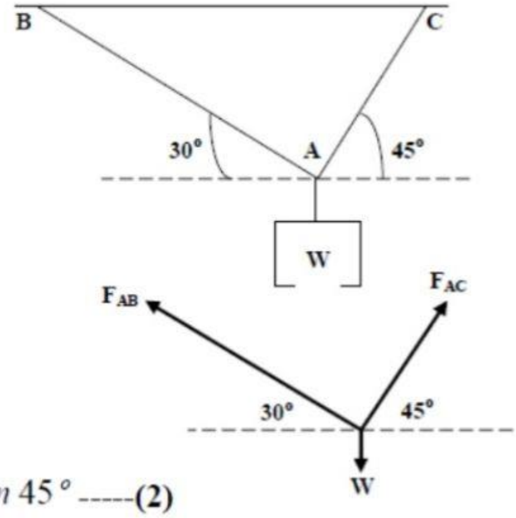
$$\sigma_{Br} = \frac{P_{Br}}{A_{Br}} = \frac{20*10^3(N)}{700*10^{-6}(m^2)} = 28.6*10^6 \frac{N}{m^2} = 28.6MPa$$ **(Compressive stress)**

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

$$\sigma_{St} = \frac{P_{St}}{A_{St}} = \frac{10*10^3(N)}{800*10^{-6}(m^2)} = 12.5MPa$$ **(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 ($400mm^2$) for wire (AB) and ($200mm^2$) for wire (AC).

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



Free-body diagram

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

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

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

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

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

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

Sub (1) in (2) :

$$W = 0.8165 F_{AC} Sin 30^\circ + F_{AC} Sin 45^\circ$$

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

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

$$(W = 33.5kN)$$

Ex4: A (1000kg) homogenous bar (AB) is suspended from two cables (AC) and (BD), each with cross-sectional area ($400mm^2$), as shown in figure. Determine the magnitude of load (P) and location (x) that is additional force which can be applied to the bar. The stresses in the cable (AC) and (BD) are limited to (100MPa) and (50MPa) respectively.

Sol:

$$\sigma = \frac{F}{A} \Rightarrow F = \sigma * A$$

$$F_{AC} = 100 * 10^{6} * 400 * 10^{-6} = 40kN$$

$$F_{BD} = 50 * 10^{6} * 400 * 10^{-6} = 20kN$$

From F.B.D and for equilibrium state :

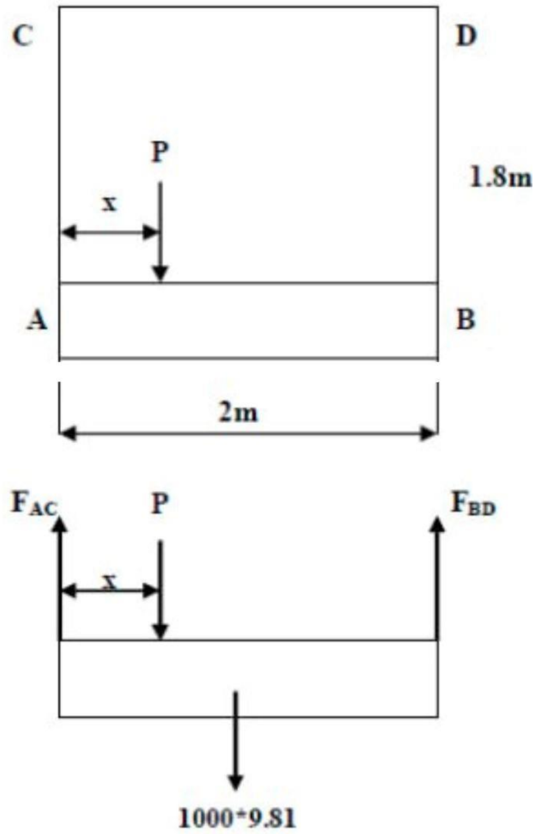
$$\sum F_y = 0$$

$$P + 9810 = 40 * 10^{3} + 20 * 10^{3}$$

$$P = 50.2kN$$

$$\sum M_A = 0 \Rightarrow 9810 * 1 + P * x = F_{BD} * 2$$

x =0.602 m



Free-body diagram