1.1. Type of Stress

The primer shape in figure (1.1) refers to resultant forces of distribution loads in sectioned area. The problem now in mechanics of materials to obtain the distribution in this sectioned area to establish stress concept

to solve this problem, we will follow this procedures:

- Subdivided the sectioned area to small areas such as ΔA shown in figure (1.1a) without space in this section this is called continuum or uniform distribution.
- These small areas must be connected without breaks, cracks, or separations.
- Every small area effected by small force ΔF and can replaced it by three components.
- These mechanism will produce the following stresses

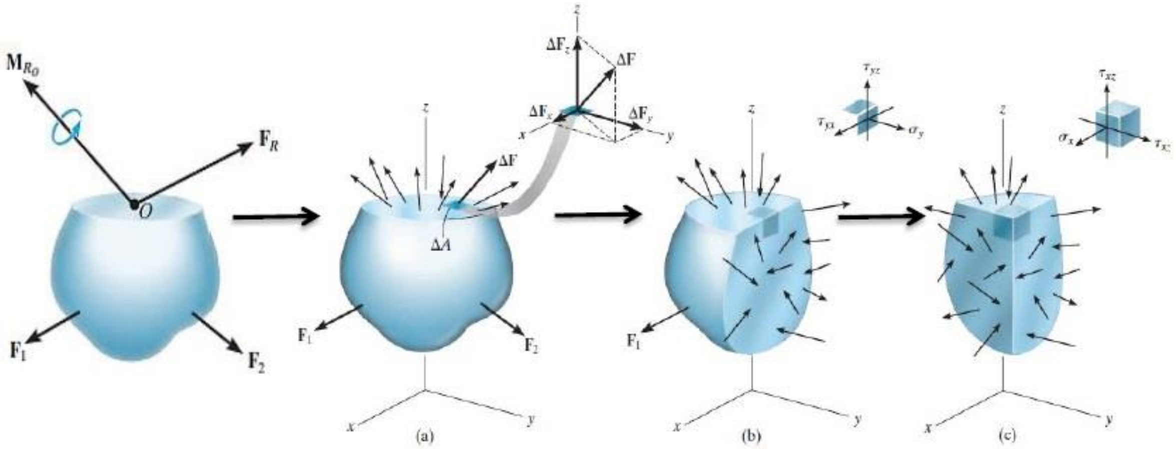


Fig (1.1) The stresses generated from internal force

1- Normal stress (σ_n)
2- Shear Stress (τ_{nn})
3- Bearing Stress

Type of stress

The intensity of the force acting normal to ΔA is called Sigma such as $\sigma_x, \sigma_y. \sigma_z$ and can translate to this equations:

$$\boldsymbol{\sigma_x = \lim_{\Delta A \to 0} \frac{\Delta F_x}{\Delta A}}$$

$$\boldsymbol{\sigma_y = \lim_{\Delta A \to 0} \frac{\Delta F_y}{\Delta A}}$$

$$\boldsymbol{\sigma_z = \lim_{\Delta A \to 0} \frac{\Delta F_z}{\Delta A}}$$

If the normal force or stress "pulls" on ΔA as shown in figure 1.2a, it is referred to as tensile stress, whereas if it "pushes" on ΔA it is called compressive stress

In other mean the resisting area is perpendicular to the applied force, thus normal. There are two types of normal stresses; tensile stress and compressive stress. Tensile stress applied to bar tends the bar to elongate while compressive stress tend to shorten the bar.

$$\sigma = \frac{p}{A}$$

Table (1.3) Engineering analysis of rod connection (bolt)

Allowable shear area	Allowable normal area	Allowable area
$\pi r^2 = \frac{\pi}{4} d^2$	$l\,t$	$t\,d$

1.2 Shear Stress (τ_{nn})

The intensity of force acting tangent to ΔA is called the Tua such as $\tau_{xy}, \tau_{xz}, \tau_{yz}$. The equations that indicate below with figure (2.1) about shear planes and tangent forces:

$$\tau_{xy} = \lim_{\Delta A \to 0} \frac{\Delta F_x}{\Delta A}$$

$$\tau_{xZ} = \lim_{\Delta A \to 0} \frac{\Delta F_y}{\Delta A}$$

$$\tau_{zy} = \lim_{\Delta A \to 0} \frac{\Delta F_z}{\Delta A}$$

Then the Average Shear Stress is:

$$\tau = \frac{V}{A}$$

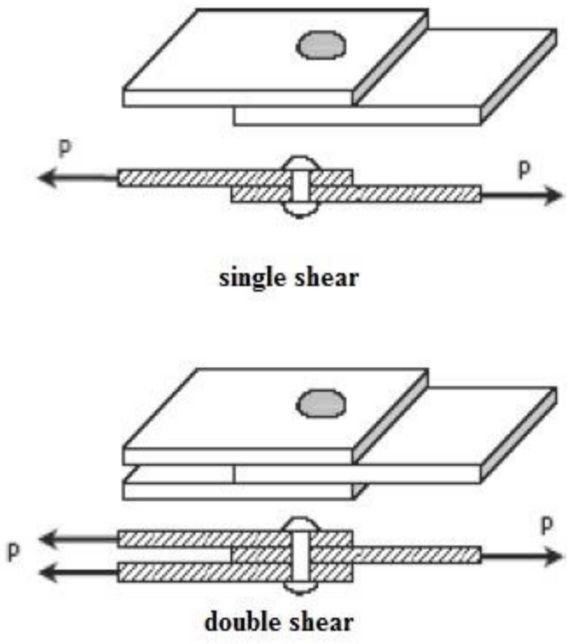
Here:

τ : Average shear stress at the section, which is assumed to be the same at each point located on the section.

V : Internal resultant shear force on the section determined from the equations of equilibrium.

A: Area at the section.

Fig (1.2)single shear and double shear



1.3 Bearing Stress (Allowable Stress):

To properly design a structural member or mechanical element it is necessary to restrict the stress in the material to a level that will be safe. To ensure this safety, it is therefore necessary to choose an allowable stress that restricts the applied load to one that is less than the load the member can fully support.

One method of specifying the allowable load for a member is to use a number called the **factor of safety** (FS).

$$FS = \frac{F_{fail}}{F_{allow}} = \frac{\sigma_{fail}}{\sigma_{allow}} = \frac{\tau_{fail}}{\tau_{allow}} \qquad (FS > 1)$$

Here :

F_{fail} : Failure load is founded by from the experimental testing of material.

FS : Factor of safety is selected from experience.

F_{allow}: Allowable load.

$$A = \frac{P}{\sigma_{allow}}$$

$$A = \frac{P}{\tau_{allow}}$$

The analysis of rod connection (bolt) area with plates as related to applied loads as the table below:

Table (3.1) Engineering analysis of rod connection (bolt)

Allowable shear area	Allowable normal area	Allowable area
$\pi r^2 = \frac{\pi}{4} d^2$	lt	td

Example 1:

A homogeneous 800 kg bar AB is supported at either end by a cable as shown in Fig(1.8). Calculate the smallest area of each cable if the stress is not to exceed 90 MPa in bronze and 120 MPa in steel.

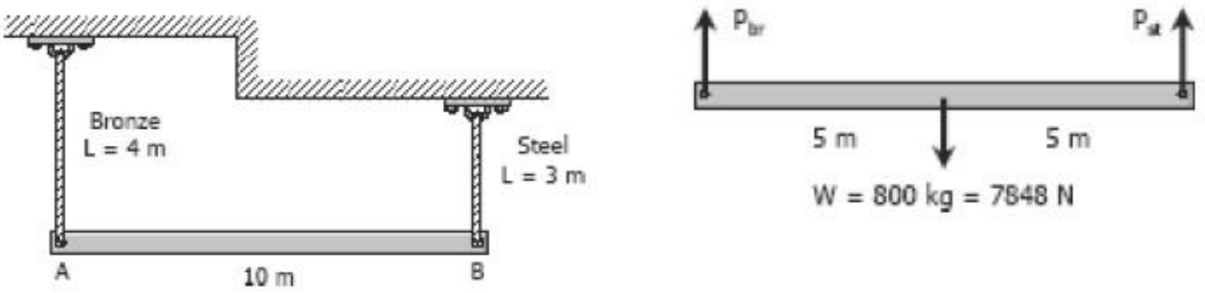


Fig (1.3**)**

Solution:

F = 800 × 9.81 = 7848 N

Assume the force of steel bar is P_{st} and the force of bronze bar is P_{br}

$P_{br} = P_{st} = \frac{1}{2}(7848) = 3924\ N$

For bronze cable

$$\sigma_{br} = \frac{P_{br}}{A_{br}} \rightarrow A_{br} = \frac{P_{br}}{\sigma_{br}} = \frac{3924}{90} = 43.6\ mm^2$$

For steel cable

$$\sigma_{st} = \frac{P_{st}}{A_{st}} \rightarrow A_{st} = \frac{P_{st}}{\sigma_{st}} = \frac{3924}{120} = 32.7mm^2$$

Example 2:

we have two bar bar1 have area 10 mm^2 and bar 2 have area 1000mm^2 as shown in fig (1.9)

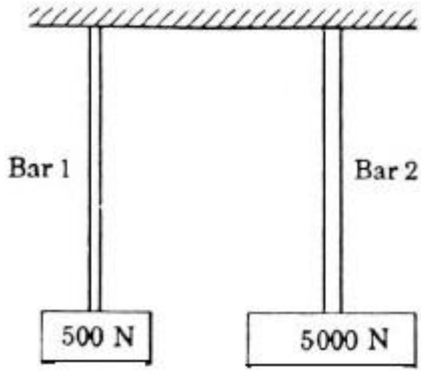
find which bar have maximum normal stress.

$$\sigma_1 = \frac{P_1}{A_1} = \frac{500}{10 \times 10^{-6}} = 50 \times 10^6 \, N/m^2$$

$$\sigma_2 = \frac{P_2}{A_2} = \frac{5000}{1000 \times 10^{-6}} = 5 \times 10^6 \, N/m^2$$

$$\sigma_1 > \sigma_2$$

Bar1 have maximum normal stress



Examble 3:

Consider the bolted joint shown in Fig.(1.4). The force *P* is 30 kN and the diameter of the bolt is 10 mm.Determine the average value of the shearing stress existing across either of the planes *a-a* or *b-b*.

Solution:

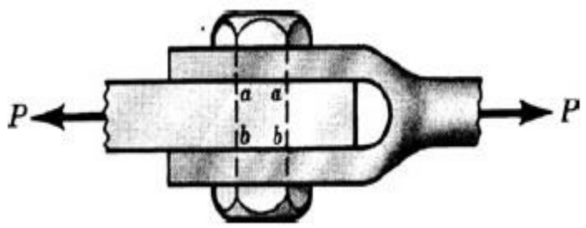
$$A = \frac{1}{4}\pi(d)^2 = \frac{1}{4}(3.14) \times (10)^2 = 78.5 \, mm^2$$

shear stress will be at planes a-a and b-b so that the force at planes

$$a - a = \frac{P}{2} \, , b - b = \frac{P}{2} = \frac{30}{2} = 15 \, KN$$

Thus the average shearing stress across either plane is

$$\tau = \frac{V}{A} = \frac{15 \times 10^3}{78.5 \times 10^{-6}} = 191 \times 10^6 \, N/m^2$$



3.1.Bearing Stress (Allowable Stress):

To properly design a **structural member** or **mechanical element** it is **necessary** to **restrict the stress in the material to a level that will be safe**. To ensure this safety, it is therefore necessary to choose an **allowable stress** that **restricts the applied load** to one that is **less than the load the member can fully support**.

One method of specifying the allowable load for a member is to use a number called the **factor of safety** (FS).

$$FS = \frac{F_{fail}}{F_{allow}} = \frac{\sigma_{fail}}{\sigma_{allow}} = \frac{\tau_{fail}}{\tau_{allow}} \qquad (FS > 1)$$

Here :

: Failure load is founded by from the experimental testing of material.F_{fail}

: Factor of safety is selected from experience.FS

Allowable load.F_{allow}:

$$A = \frac{P}{\sigma_{allow}}$$

$$A = \frac{P}{\tau_{allow}}$$

Example (3.3):

The lap joint shown in fig (1.4)is fastened by three 20mm diameter rivets assuming that P=50KN determine

a. The shearing stress in each rivet.
b. The bearing stress in each plate.

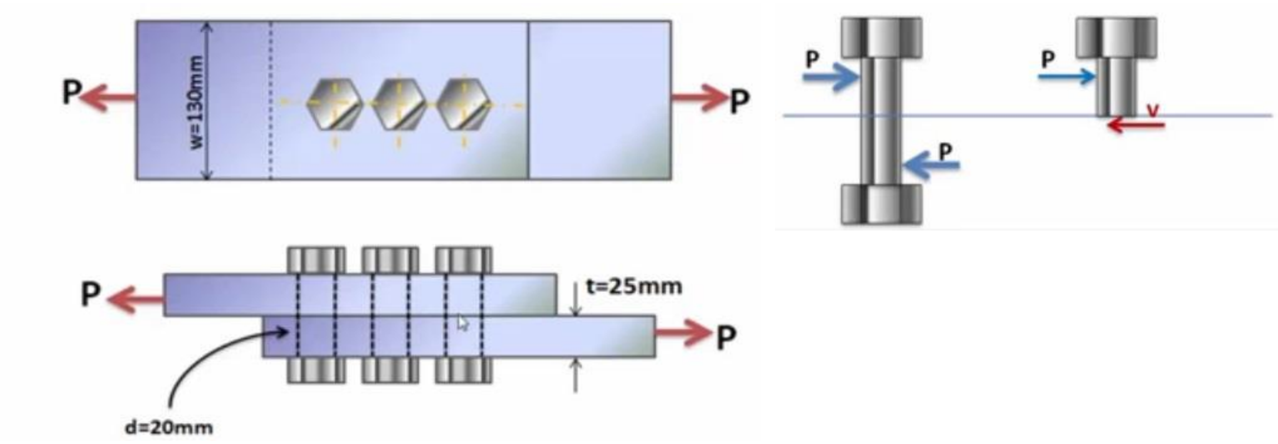


Fig (1.4)

Solution:

a. $P = \frac{50}{3} = 16.666\ KN$

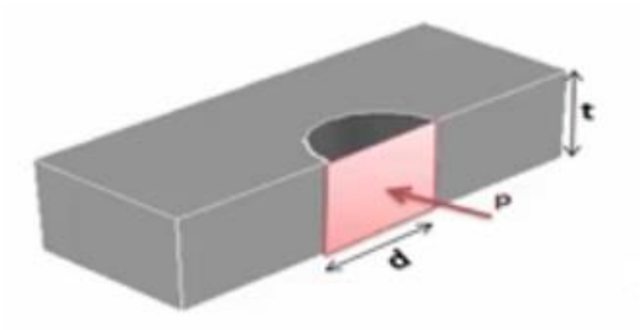
$$\tau = \frac{P}{A} = \frac{P}{\frac{\pi}{4}d^2} = \frac{16.666 \times 10^3}{\frac{\pi}{4}(20)^2 \times 10^{-6}} = 53.07\ N/m^2$$

$= 53.07\, N/m^2$

Than $\tau = 53.07\ \ N/m^2$

in each rivet

$$\boldsymbol{b}.\ \ P = \frac{50}{3} = 16.666\, KN$$



$$\sigma_b = \frac{P}{A_b} = \frac{P}{td}$$

$$= \frac{16.666 \times 10^3}{25 \times 20 \times 10^{-6}}$$

$$= 33.34\ \ N/m^2$$