Strength of materials

Second Class

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2024-2025

B- Shear Stress:

Shearing stress differs from both tensile and compressive stress in that is caused by forces acting along or parallel to the area resisting the force where's tensile and compressive stress are caused by forces perpendicular to the area on which they act. For this reason, tensile and compressive stresses are frequently called (*Normal Stresses)* where's shearing stress may be called (*Tangential Stresses*)**.**

I- ***Direct shear stress***
- ***Single shear stress***
- ***Double shear stress***

II- ***Punching shear stress: the force tends to drill the loaded body.***

$$\tau = \frac{V}{A_{sh.}}$$

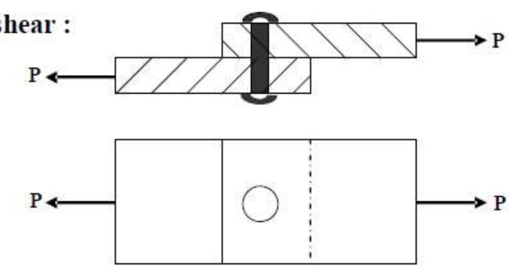
where: (V) ……. shearing load

($A_{sh.}$) ………shearing area (parallel area)

In single shear , there is single area of shear :

$$\tau = \frac{P}{\frac{\pi}{4} d^2}$$

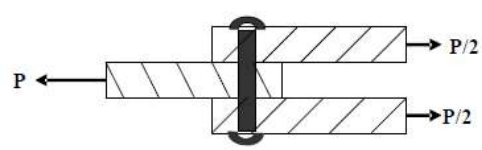
d ------- Diameter of area parallel to load direction (m) .



(Single shear)

In double shear , there are two area of shear :

$$\tau = \frac{P}{2 * \frac{\pi}{4} d^2}$$

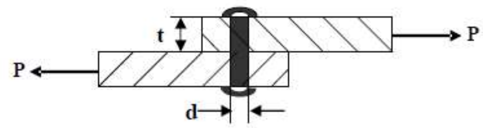


(Double shear)

C- Bearing (Crushing) Stress:

Bearing stress differs from compressive stress in that the latter is the internal stress caused by a compressive force where's the former is a contact pressure between separate bodies.

$$\sigma_{cr} = \frac{P}{A_{cr}} = \frac{P}{d * t}$$

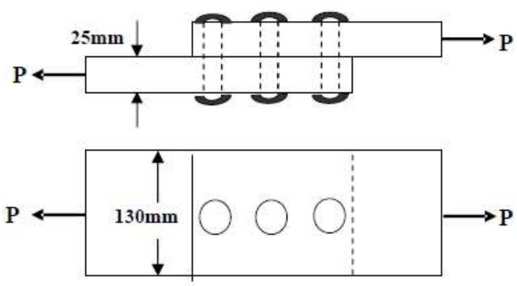


Where :

A_{cr}-------Bearing (Crushing) area

Ex: The lap joint shown in figure is fastened by three (20mm) diameter rivets . Assuming that (P=50kN) applied determine : 1) The shearing stress in each rivet . 2) The bearing stress in each plate. 3) The maximum average tensile stress in each plate . Assume that the applied load (P) is distributed equally among the three rivets .

Sol:



1) $\tau = \frac{P}{A_{sh}} = \frac{P}{3A_r}$

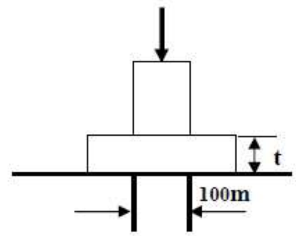
$$\tau = \frac{50*10^3}{3\left[\frac{\pi}{4}(0.020)^2\right]} = 53.1MPa$$

2) $\sigma_b = \frac{P_b}{A_b} = \frac{P}{3*d*t} = \frac{50*10^3}{3*0.02*0.025} = 33.3MPa$

3) $\sigma_t = \frac{P}{A_{plate}} = \frac{P}{(w-d)*t} = \frac{50*10^3}{(0.13-0.02)*0.025} = 18.2MPa$

Ex: As shown in figure, a hole is to be punched out of a plate having an ultimate shearing stress of (300MPa). 1)If the compressive stress in the punch is limited to (400MPa), determine the maximum thickness of plate from which a hole (100mm)in diameter can be punched . 2)If the plate is (10mm) thick, compute the smallest diameter hole which can be punched.

Sol:



1) $$\sigma_{comp.} = \frac{P}{A}$$

$$P = \sigma * A = 400*10^6 * \frac{\pi}{4}(0.1)^2$$

$$\boldsymbol{P = 3141.6kN}$$

$$\tau = \frac{V}{A} \Rightarrow A = \frac{V}{\tau} \Rightarrow \pi * d * t = \frac{3141.6*10^3}{300*10^6}$$

$$t = 33.33\,mm$$

2) $$\sigma_{comp.} = \frac{P}{A}$$

$$P = \sigma_{comp.} * A = 400*10^6 * \frac{\pi}{4}d^2$$

$$\tau = \frac{\sigma * A}{\pi * d * t}$$

$$300*10^6 = \frac{400*10^6 * \frac{\pi}{4}d^2}{\pi * d * 0.01}$$

$$\therefore d = 30\,mm$$

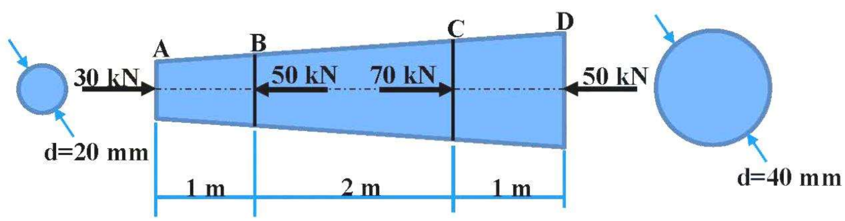
Notes

1- Both normal and shear stresses have uniform distribution
2- To specify the allowable load for the design or analysis, a number called (factor of safety) is used, and denoted by (F.S) which is the ratio between the ultimate stress(failure load) to the allowable stress (allowable load)

$$F.S = \frac{\sigma\ ULT}{\sigma\ ALLOW} \text{ OR } F.S = \frac{\tau ULT}{\tau\ ALLOW} \text{ OR } F.S = \frac{P\ ULT}{P\ ALLOW}$$

3- In general, there are two types of problems:
   a- Analytical:
   - Knowing applied loads, dimensions and finding stress
   - Knowing allowable stress, dimensions and find allowable loads
   b- Design problems:
   - Knowing applied loads, allowable stress and finding the dimensions

Example: a round tapered alloy bar (4m) long is subjected to load as shown in figure bellow. Find the stresses in section at point B and section at point C.



Sol/

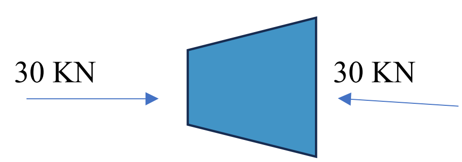
The diameter of bar at point B is : d_B= 20+(40-20)(1/4)=25 mm

Diameter of bar at point C is : d_C=25+(40-20)(2/4)=35mm

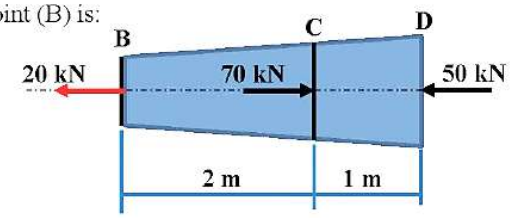
So the area at point B is A_B= 490.87 mm2

Stress just to the left of the point is

σ_B=P/A= 30*10^3/490.87= 61.12 MPA



▶ Just to the right of point (B) is:



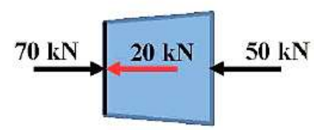
$$\sigma_B = \frac{P}{A} = \frac{20 \times 10^3}{490.87} = 40.74\ MPa$$

▶ The area at point (C) is:

$$A_C = \frac{\pi}{4}(d^2) = \frac{\pi}{4}(35)^2 = 962.11\ mm^2$$

▶ Just to the left of point (C) is:

$$\sigma_C = \frac{P}{A} = \frac{20 \times 10^3}{962.11} = 20.79\ MPa$$



▶ Just to the right of point (C) is:

$$\sigma_C = \frac{P}{A} = \frac{50 \times 10^3}{962.11} = 51.97\ MPa$$