MADE EASY

CIVIL ENGINEERING

Strength of Material

BY-Rishi Sir

- Theory
- Explanation
- Derivation
- Example
- Shortcuts
- Previous Years Question With Solution

PROPERTIES OF MATERIALS

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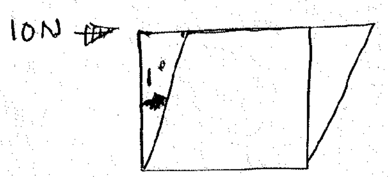
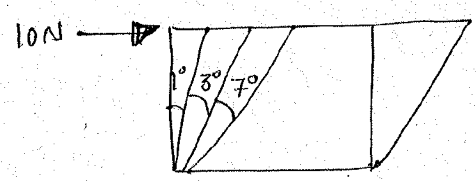
Rishi sir

1-a

Engg. Science
- Solid Mechanics
- Fluid Mechanics
- Properties of Material



t=2sec → 1°
t=5sec → 1°
t=10sec → 1°



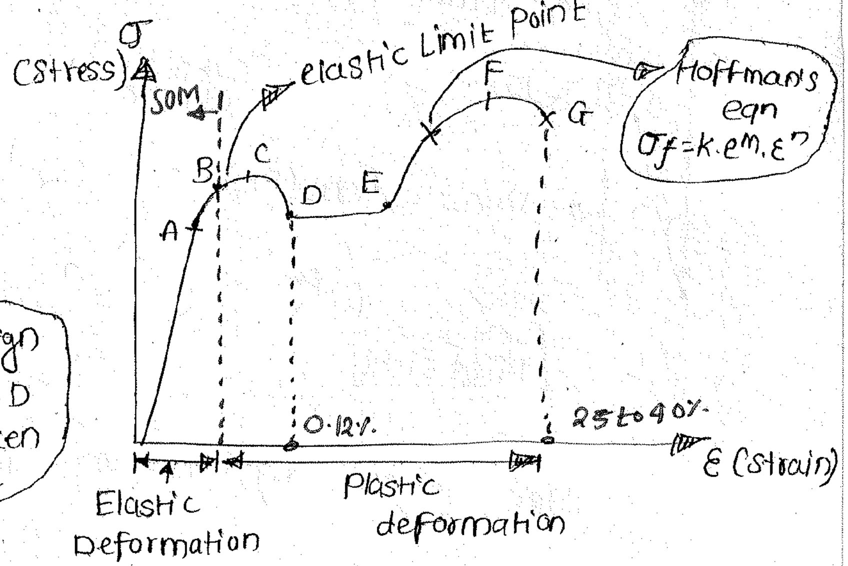
t=2sec = 1°
t=5sec = 3°
10sec = 7°

Solid Mechanics
- Engg. Mechanics
- SOM / MOS / MOHDB → Mechanics of Highly Deformed Body.

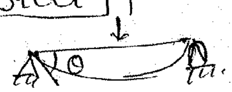
Deformation
- Elastic
- Plastic

upto A, $\sigma \propto \epsilon$

for design A, B, C, D is taken same



Steel



$\delta = \frac{PL^3}{48EI}$

δ, θ very small

$$\frac{M}{I} = \frac{\sigma}{y} = \frac{E}{R}$$

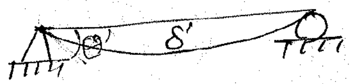
$$\frac{1}{R} = \frac{d^2y/dx^2}{\left[1+\left(\frac{dy}{dx}\right)^2\right]^{3/2}}$$

($\frac{dy}{dx} \to 0$)

$$\Rightarrow \frac{1}{R} = \frac{d^2y}{dx^2} \Rightarrow \frac{M}{EI} = \frac{d^2y}{dx^2}$$

$$\boxed{M = EI.\frac{d^2y}{dx^2}}$$

Hard Rubber



$\delta' \neq \frac{PL^3}{48EI}$ $\frac{1}{R} \neq \frac{d^2y}{dx^2}$

δ', θ' is Large

$$\frac{1}{R} = \frac{d^2y/dx^2}{\left[1+\left(\frac{dy}{dx}\right)^2\right]^{3/2}}$$

$\frac{dy}{dx} \neq 0$

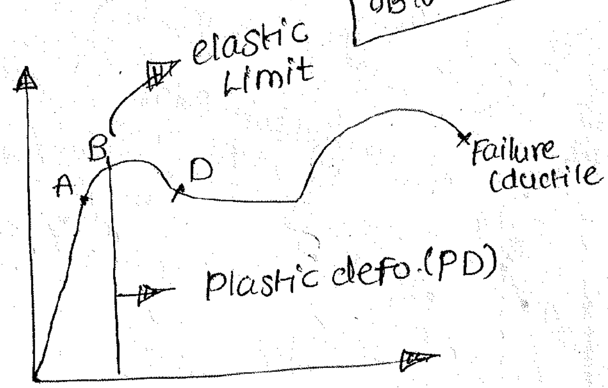
Plastic Deformation is greater than Elastic Deformation

1-(b)

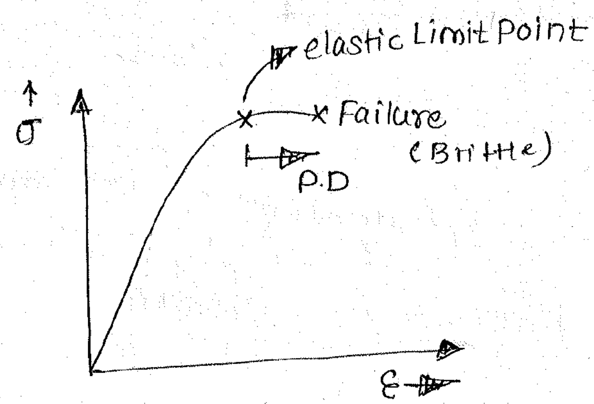
Failure Of Material :-

- Plastic Deformation (Ductile)
- Fracture (Brittle)

$\sigma_B \approx \sigma_D \simeq 250 MPa$



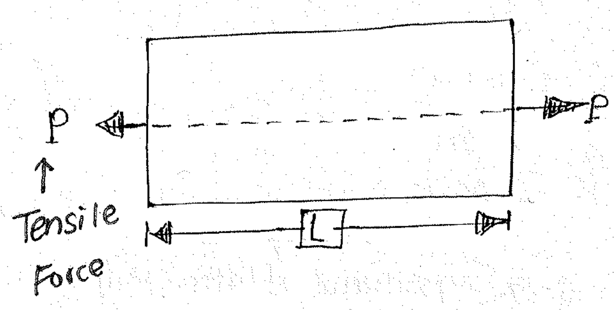
Mild steel

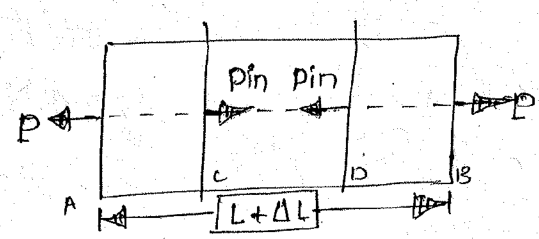


Cast Iron

More Plastic deformation More ductility

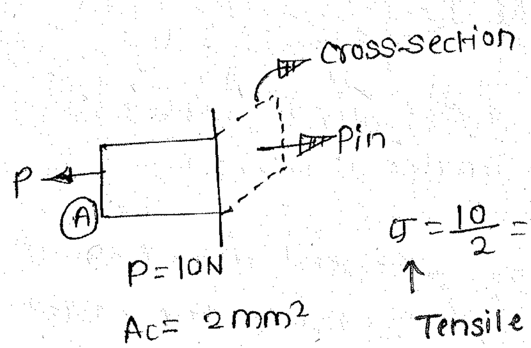
*. Difference B/w Strength and Stress :





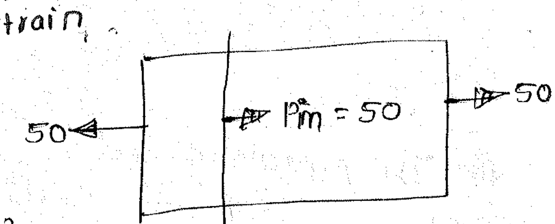
$$\varepsilon = \frac{\Delta L}{L}$$

Tensile strain

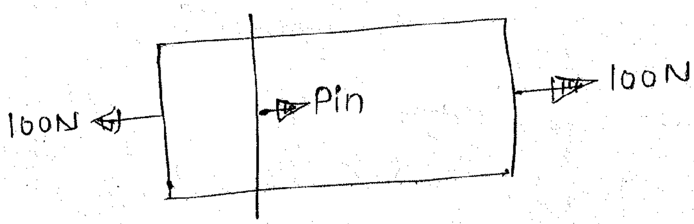


$$\sigma = \frac{10}{2} = 5\ N/mm^2$$

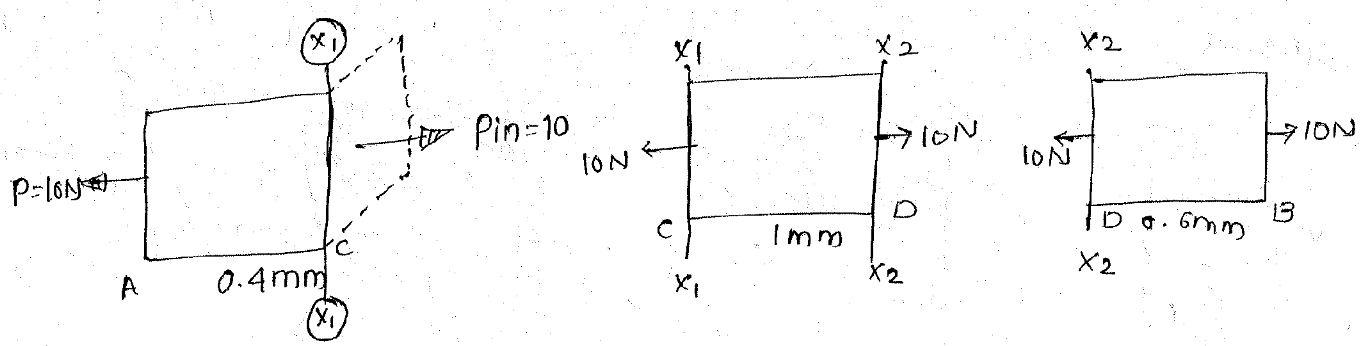
↑ Tensile Stress



$$\sigma = \frac{50}{2} = 25 MPa$$



$$\sigma = \frac{100}{2} = 50 MPa \Rightarrow \text{Strength}$$



→* Strain is a cause of Stress.

Stress is a internal resisting force offered by material against deformation.

* Hook's Law: (Axial Deformation)

$\varepsilon = \frac{\Delta L}{L}$

$\sigma = \frac{P_{in}}{A_c} = \frac{P}{A}$

Hook's Law

$\sigma \propto \varepsilon$

$\sigma = E\varepsilon$

$\varepsilon = \frac{\sigma}{E} = \frac{P/A}{\Delta L/L}$

$$\boxed{\Delta L = \frac{PL}{AE}} \Rightarrow \text{(Constitutive relationship.)}$$

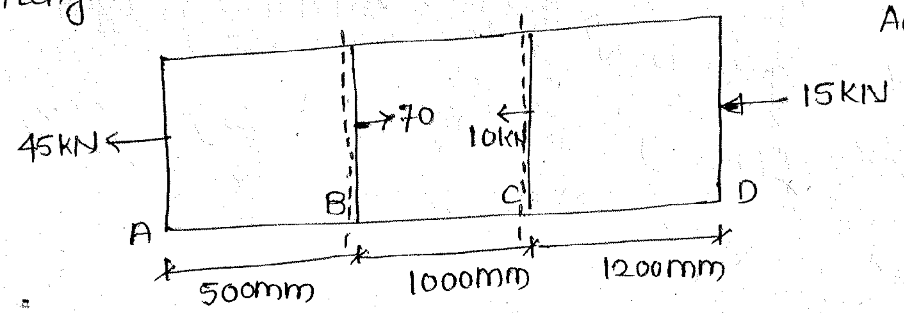
The equation relating stress and strain is called Constitutive Equation because, it depend on material behaviour.

Statically determinate problem.

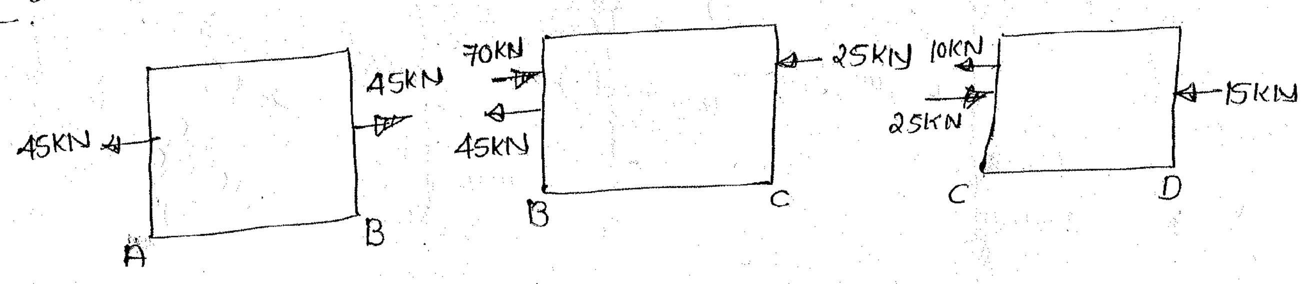
Que: A rectangular c/s Bar having cross-sectional area $800 mm^2$ is subjected to axial Loading as shown. Determine the total change in Length of Bar.

$E = 100 GPa$

$A_c = 800 mm^2$



Sol^n:–



$\Delta_{Total} = \Delta_1 + \Delta_2 + \Delta_3$

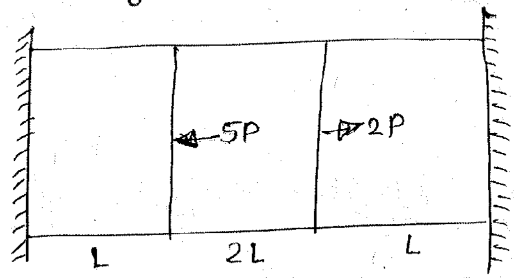
$$= \frac{1}{(800 mm^2)(100 \times 10^3) \frac{N}{mm^2}} \left[\{(45 \times 10^3)(500)\} + ((-25 \times 10^3)(1000)) + ((-15 \times 10^3) \times 1200) \right]$$

$= -0.25625 mm$

Que: $E = 100\ GPa$

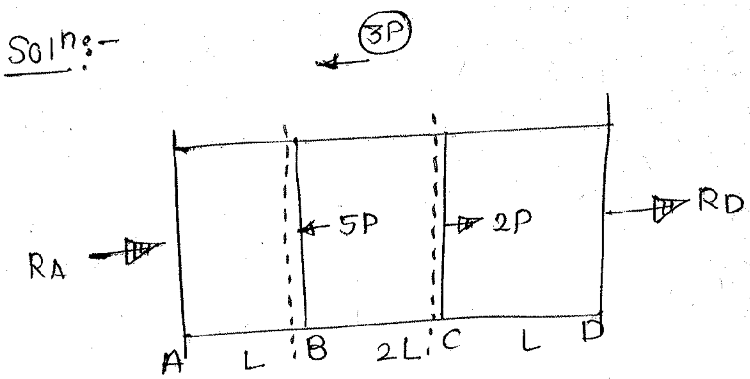
$A_c = 800\ mm^2$

Statically Indeterminate Problem

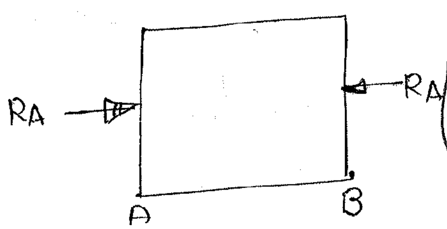


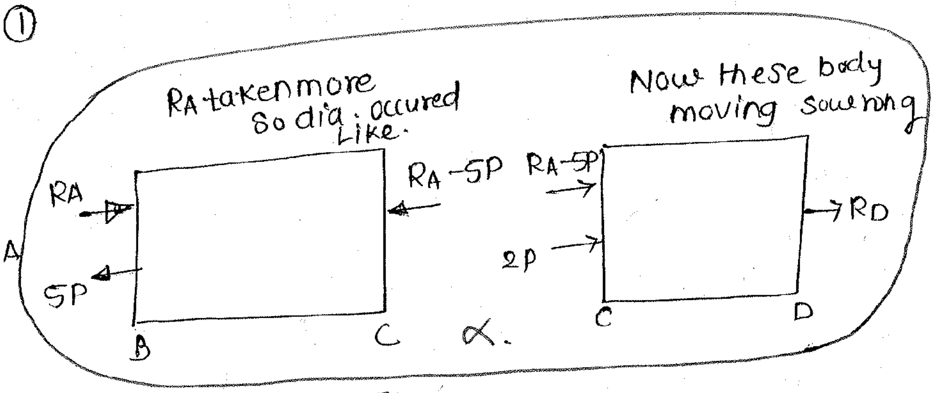
A bar arrangement as shown. Determine Support Reaction and draw axial Force diagram

Soln:-

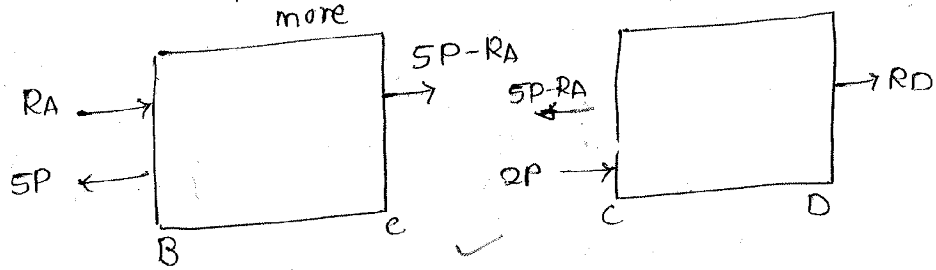


$R_A + R_D = 3P$ — ①





Now taken 5P more



$5P - R_A - R_D - 2P = 0$

$\boxed{R_A + R_D = 3P}$ checked.

$\Delta_{Total} = 0$ (bcz both ends are fixed)

$\Delta_1 + \Delta_2 + \Delta_3 = 0$ (compatibility eqn)

$$\frac{1}{AE}\left[\{(-R_A \cdot L)\} + \{(5P - R_A)2L\} + \{(+R_D \cdot L)\}\right] = 0 \quad \text{——} ②$$

$$-R_A \cdot L + 10PL - 2R_AL + R_D \cdot L = 0$$

$$-R_A + 10P - 2R_A + R_D = 0$$

$$-3R_A + 10P + R_D = 0$$

$$3R_A - R_D = 10P \quad \text{—②}$$

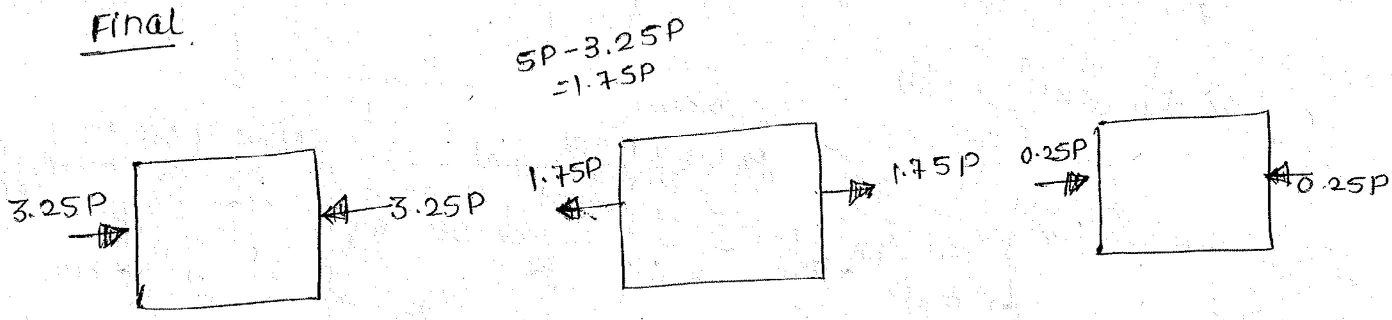
$$R_A + R_D = 3P \quad \text{—①}$$

$$4R_A = 13P$$

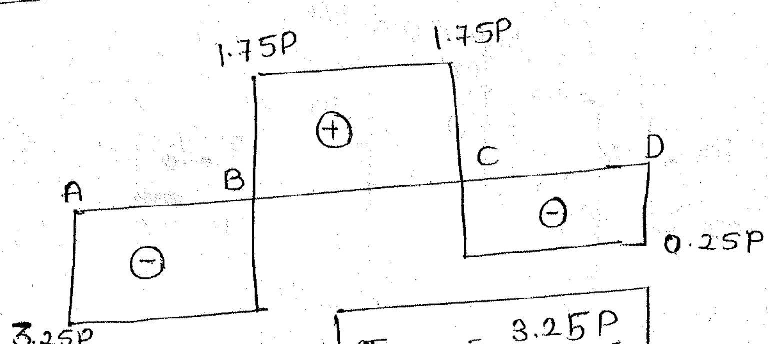
$$R_A = \frac{13P}{4} = \boxed{3.25P}$$

$$\boxed{\therefore \; R_D = -0.25P}$$

Final



Axial Force Diagram : (equillibrium Diagram)



$$\boxed{\sigma_{max} = \frac{3.25P}{A_c}}$$

Compatibility Equation is the relationship b/w unknown forces and known Deformation.

* Stress Tensor:

Scalar → Magnitude → Zero order Tensor

Vector → Mag + Dire^n → Ist order Tensor F_x, F_y

Tensor → (Direction + plane) → 2nd order Tensor

↓

Stress, strain, M.I, P.M.O.I. (polar M.I.)

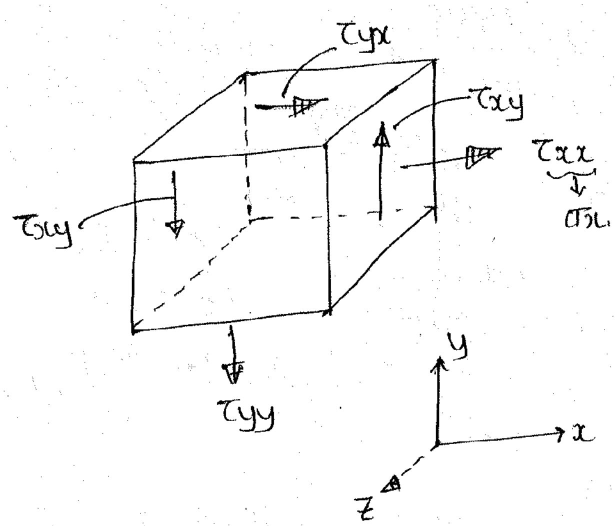
τ_{xy}, τ_{xz}, σ_x → τ_{xx}.

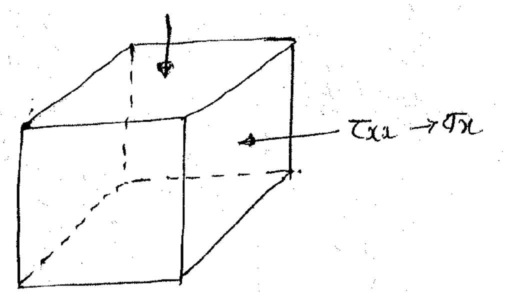
Stress Representation:

τ_{ij} → j represent the stress direction

i → represent the plane (outward Normal) at which stress acting.

τ_{yy} } σ_y $\tau_{zz} \to \sigma_z$



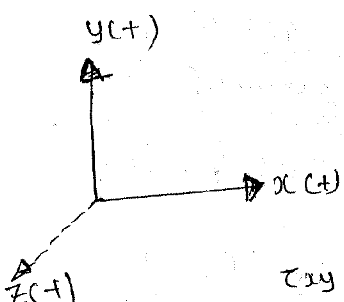


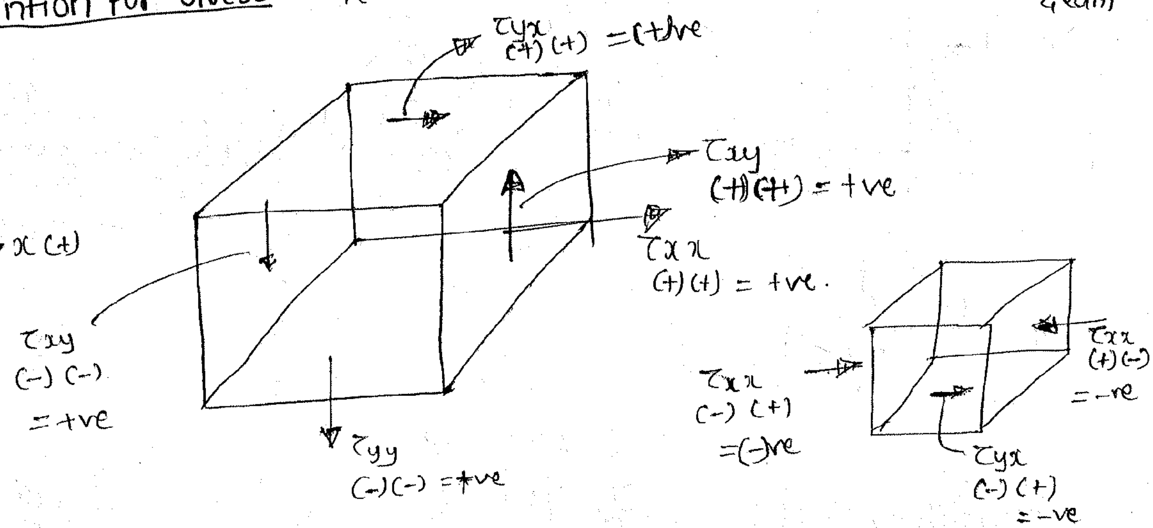
τ_{xx}, τ_{yy} → Normal Stress

$\tau_{xy}, \tau_{yz}, \tau_{zy}$ → shear stress.

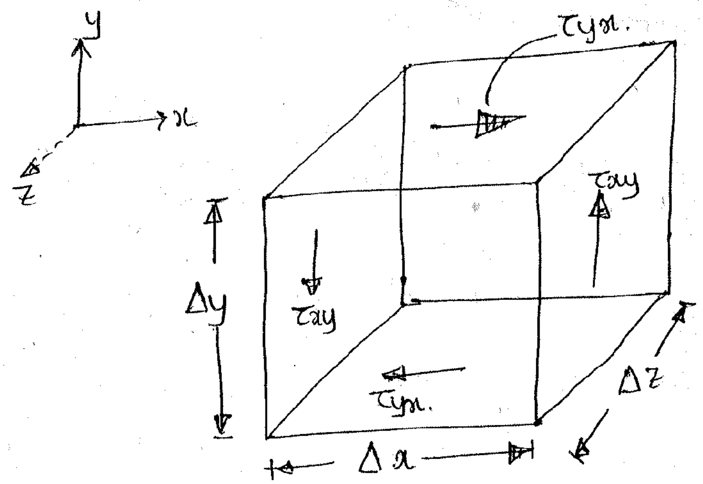
* Sign Convention for stress:

पहले subscript में plane को देखना then arrow को देखना



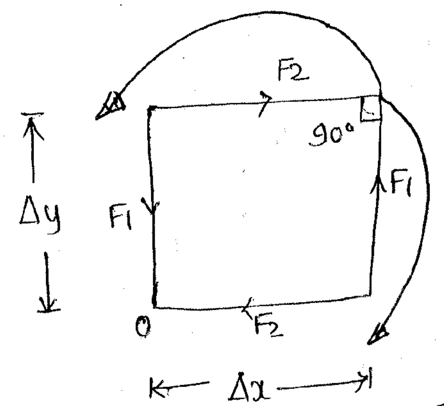


Equality Of Shear Stress: (2.10)



$$F_1 = \tau_{xy}\,(\Delta z . \Delta y)$$

$$F_2 = \tau_{yx}\,.\,(\Delta x . \Delta z)$$



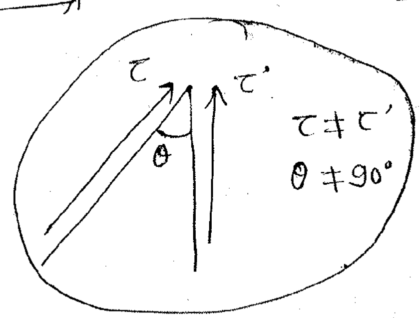
By moment Equillibrium condition

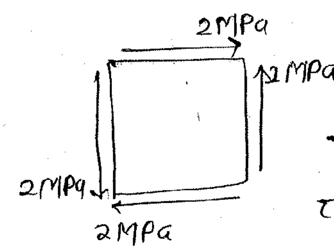
$$\Sigma M_O = 0$$

$$F_1 . \Delta x = F_2 . \Delta y$$

$$\tau_{xy} . (\Delta z . \Delta y)\Delta x = \tau_{yx} . (\Delta x . \Delta z) . \Delta y$$

$$\boxed{\tau_{xy} = \tau_{yx}}$$



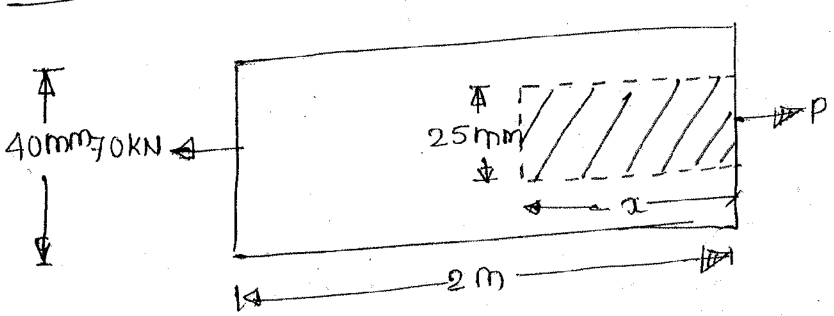


$$\tau_{xy} = \tau_{yx}$$

$$\tau_{xz} = \tau_{zx}$$

$$\tau_{yz} = \tau_{zy}$$

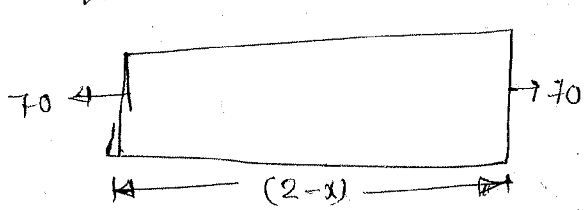
Que:6: WB: CH-02

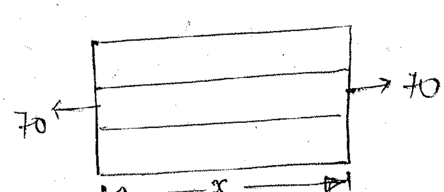


When No Boring

$$\delta = \frac{(70\times10^3)\,(2\times10^3)}{\frac{\pi}{4}(40)^2\,(E)}$$

When Boring complete





$$\delta_1 = \frac{(70\times10^3)\,(2-x)\times10^3}{\frac{\pi}{4}(40)^2 \times E}$$

$$\delta_2 = \frac{(70\times10^3)(x\times10^3)}{\frac{\pi}{4}(40^2-25^2)E}$$