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

BY- KANCHAN SIR

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Strength of Materials

By. Kanchan Thakur

Content

- ① Properties of materials & Axial stress. *****
- ② Shear force and bending moment diagram. *****
- ③ Bending stress. *****
- ④ Transverse shear stress. ***
- ⑤ Torsion ****
- ⑥ Transformation of stress & strain *****
- ⑦ Combined stresses *****
- ⑧ Thick & Thin cylinder *
- ⑨ Springs *
- ⑩ columns *

Properties of material & Axial stress

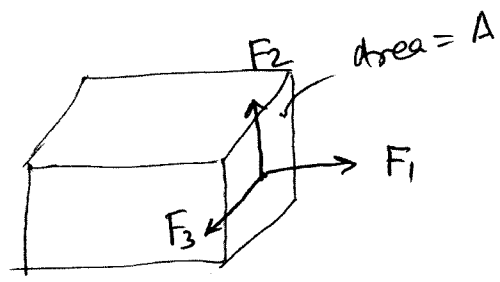
→ stress develops in a body on account of resistance against the force of deformation.

Hence,

$$\text{stress} = \frac{\text{Resisting force}}{\text{Area}}$$

→ stresses are of two types —

- (a) Normal stress
- (b) Shear stress.

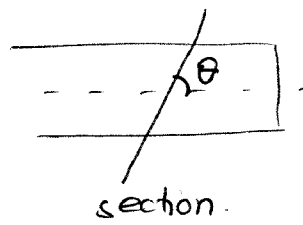
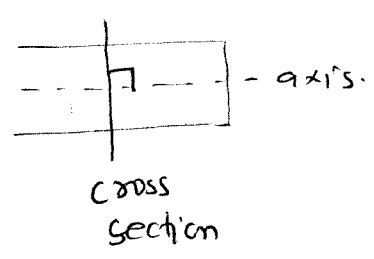


$$\frac{F_1}{A} = \text{normal stress} = \sigma$$

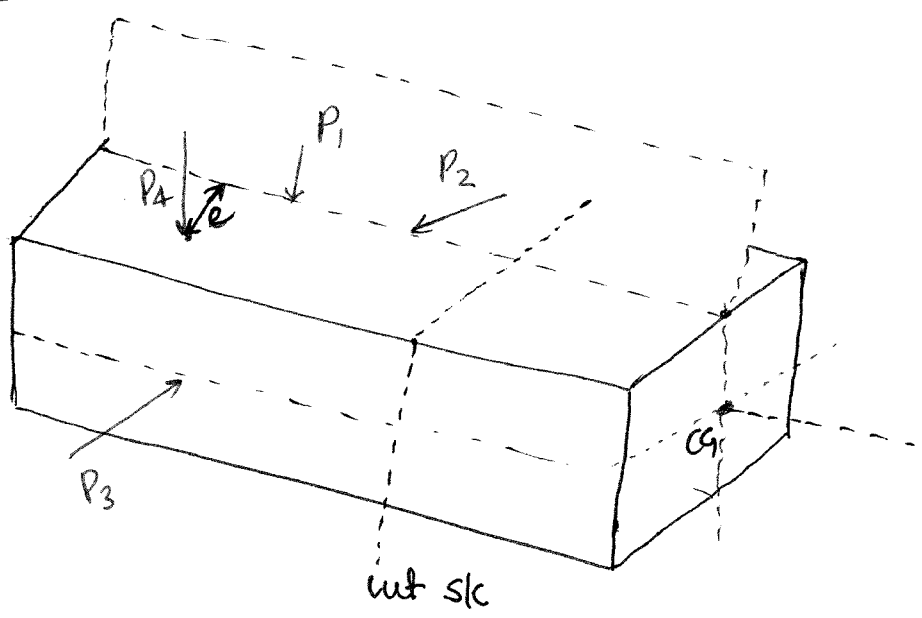
$$\frac{F_2}{A} = \text{shear stress} = \tau_2$$

$$\frac{F_3}{A} = \text{shear stress} = \tau_3$$

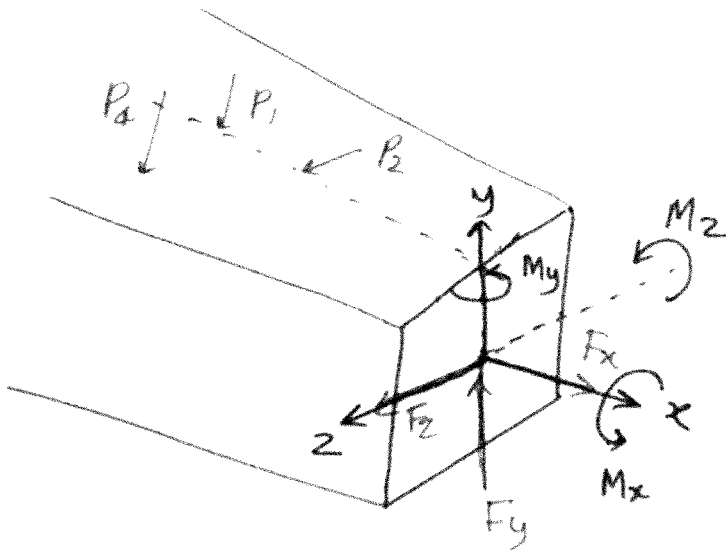
→ Normal stress acts perpendicular to the section and shear stress act along the cross section.



External forces & Internal forces :



→ P_1, P_2, P_3 & P_4 are external forces applied by some external agent (outside the beam).



→ F_x, F_y, F_z , and M_x, M_y, M_z are internal forces.

→ Internal forces developed due to external forces or external effect.

→ Maximum no. of internal forces at any section under general loading condition is $\textcircled{6}$ [F_x, F_y, F_z & M_x, M_y, M_z]

→ A body is said to be in equilibrium if summation of all forces is equal to zero and summation of all moment is equal to zero.

$$\left. \begin{aligned} \text{i.e. } \sum (\text{all forces}) &= 0 \\ \sum (\text{all moment}) &= 0 \end{aligned} \right\} \text{eqm equation.}$$

→ If a body is in equilibrium then every part of the body will also be in equilibrium.

→ Direction of moment is given by right hand thumb rule.

→ Under general case of loading we have 6 equilibrium equations:—

$$\begin{array}{l|l} \sum F_x = 0 & \sum M_x = 0 \\ \sum F_y = 0 & \sum M_y = 0 \\ \sum F_z = 0 & \sum M_z = 0 \end{array}$$

→ Types of force :

F_x = Axial force = generates normal stress called axial stress

F_y, F_z = Transverse shear force. → generates Transverse shear stress

M_x = Twisting moment → generates Torsional shear stress

M_y, M_z = Bending moment. → generates normal stress called Bending stress.

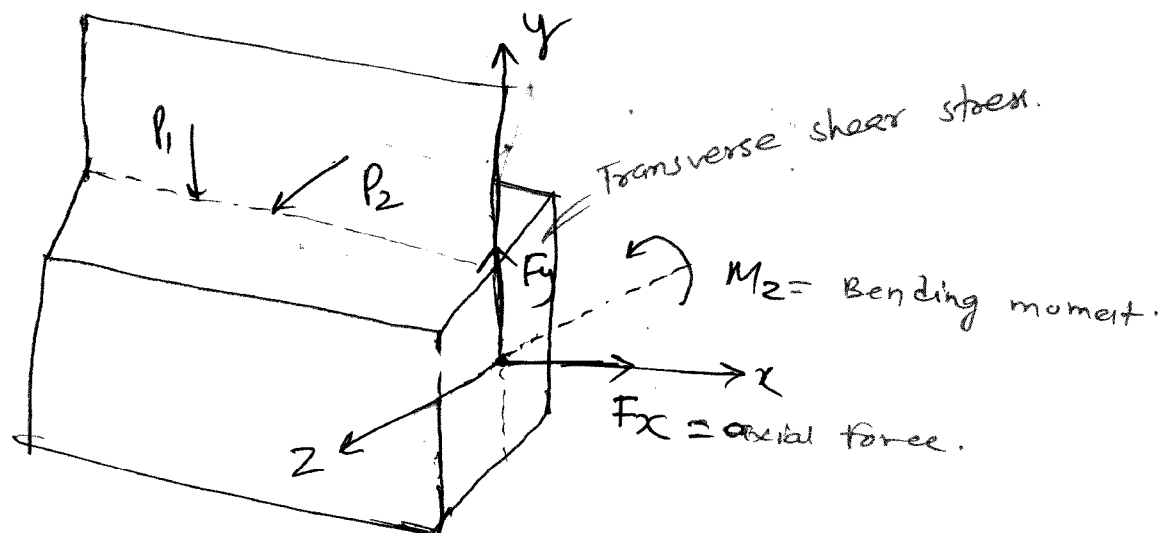
→ Under general case of loading different types of internal forces developed are -

- axial force
- Transverse shear force
- Bending moment
- Twisting moment

→ These internal forces will generate two types of stress -

- Normal stress
- shear stress.

→ 2D loading : (all loads are in same plane).



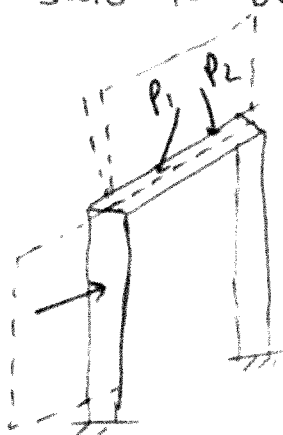
In case of 2D ^{transverse} loading or planar loading maximum no. of internal forces at any section would be (3)

They will be -

- axial force
- shear force
- Bending moment.

Note:

If structure and loading are in same plane then the structure is said to be 2D-structure.

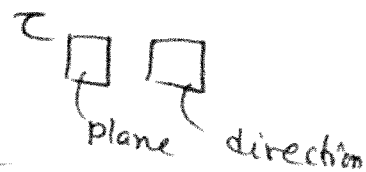
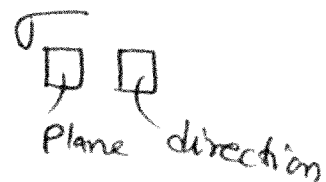
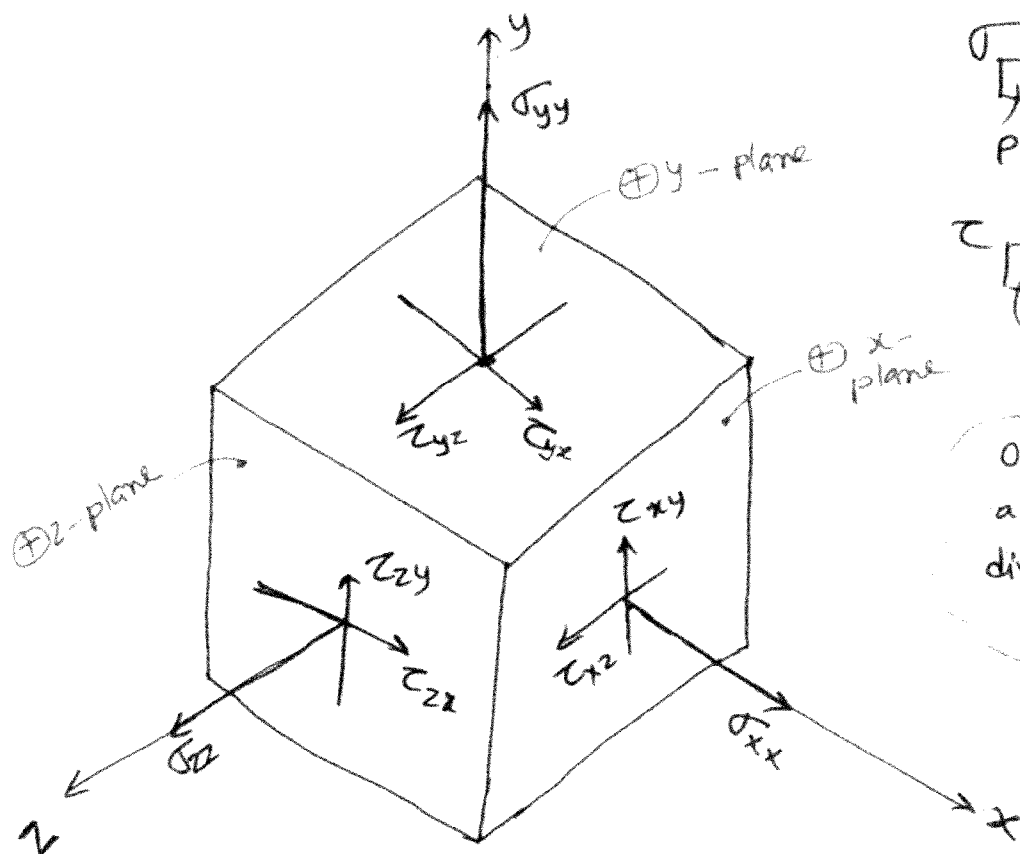


⇒ 2D-structure



3D-structure

stresses under general loading condition :



Outward normal to a plane gives the direction of the plane

→ At any point under general loading condition no. of stress³ components are (9)

→ $\sigma_{xx}, \sigma_{yy}, \sigma_{zz}$ → normal stress = 3

→ $\tau_{xy}, \tau_{yx}, \tau_{yz}, \tau_{zy}, \tau_{zx}, \tau_{xz}$ → shear stress = 6

Sign convention for stress:

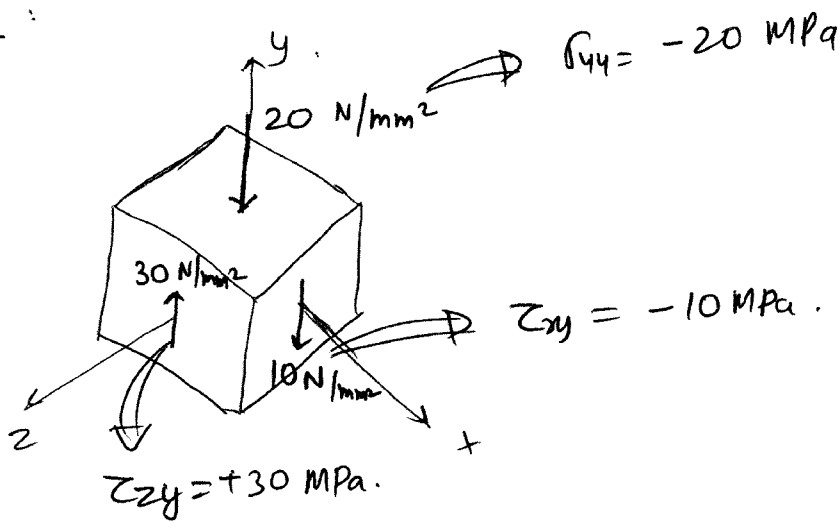
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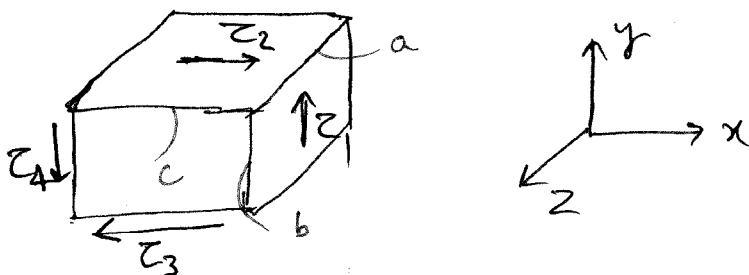
Example:



Note:

for normal stresses we can have the sign convention alternatively given as tensile stress ⇒ ⊕ ve, compressive stress ⇒ ⊖ ve

Equality of shear stresses:



$$\sum F_y = 0 \Rightarrow +\tau_1 \times ab - \tau_4 \times ab = 0 \Rightarrow \boxed{\tau_1 = \tau_4}$$

$$\sum F_x = 0 \Rightarrow \boxed{\tau_2 = \tau_3}$$

$$\Rightarrow \sum M_2 = 0 \Rightarrow -\tau_2 acb + \tau_1 abc = 0$$

$$\Rightarrow \boxed{\tau_1 = \tau_2}$$

→ Shear stresses on opposite faces of an stress element are equal in magnitude and opposite in direction.

(This statement is on account of force equilibrium)

→ shear stresses on adjacent perpendicular are equal in magnitude and are oriented in such a way that either both of them points towards the junction or they point away from the junction.

(This statement follows from moment equilibrium)

$$\text{i.e. } \tau_{xy} = \tau_{yx}$$

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

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

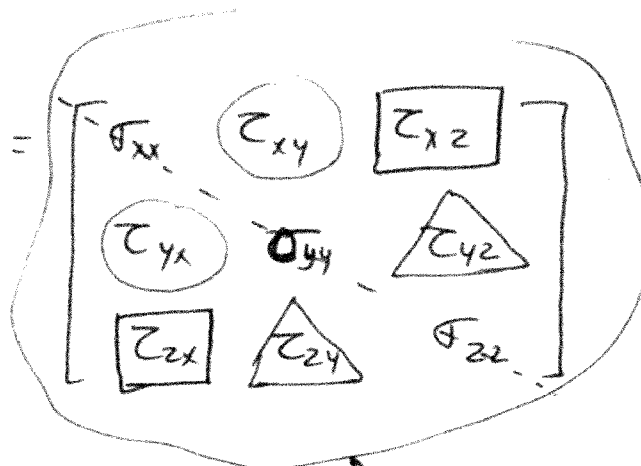
} from moment equilibrium.

→ At any point under general loading condition no. of distinct stress components are 6.

$$\sigma_{xx}, \sigma_{yy}, \sigma_{zz}, \tau_{xy} = \tau_{yx}, \tau_{xz} = \tau_{zx}, \tau_{yz} = \tau_{zy}$$

stress tensor

stress at a point =



↘ stress tensor.