## Bending Shearing Stresses ($\tau$)

$$\tau = \frac{VQ}{Ib}$$

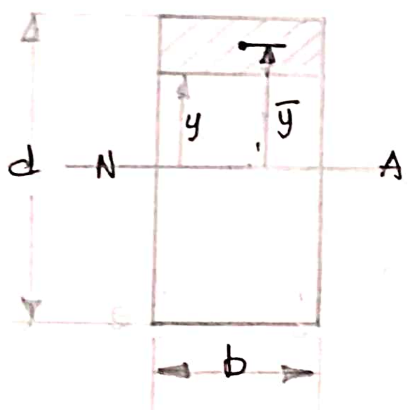
$\tau$ – Bending shear stress at a point in the cross-section

$Q$ – first moment of area $= A\bar{y}$

$I$ = Area moment of inertia of the cross-section

$b$ = breadth of the cross-section.

## Variation of Bending Shear stress in a Rectangular cross-section.




We want to find the bending shear stress $\tau$ at a distance $y$ from the neutral axis.

Draw a horizontal line at a distance $y$ from the neutral axis. Shade the area from this line to the top layer. → Area A. Find the centroid of this shaded area.

Find the distance from the neutral axis to this centroid. this distance is $\bar{y}$.

Find $A\bar{y}$. ⇒ $Q$ = first moment of Area

The shear force V, Area moment of inertia I and breadth b do not change. These three parameters remain the same.

If we want to find the bending shear stress at a layer at some other distance from neutral axis, we have to calculate the new '$Q$'. V, I and b remain the same.

2-16

$$\tau = \frac{VQ}{Ib} = \frac{V}{Ib}\underbrace{\left(\frac{d}{2}-y\right)b}_{\substack{\text{Area of}\\ \text{shaded region}}}\underbrace{\left\{y+\frac{1}{2}\left(\frac{d}{2}-y\right)\right\}}_{\bar{y}}$$

$$\tau = \frac{V}{I}\left(\frac{d}{2}-y\right)\left(y+\frac{d}{4}-\frac{y}{2}\right)$$

$$\tau = \frac{V}{I}\left(\frac{d}{2}-y\right)\left(\frac{y}{2}+\frac{d}{4}\right)$$

$$\tau = \frac{V}{I}\left(\frac{d}{2}-y\right)\frac{1}{2}\left(y+\frac{d}{2}\right)$$

$$\tau = \frac{V}{I}\cdot\frac{1}{2}\left(\frac{d}{2}+y\right)\left(\frac{d}{2}-y\right)$$

$$\tau = \frac{V}{I}\frac{1}{2}\left(\frac{d^2}{4}-y^2\right)$$

Maximum bending shear stress occurs when $y=0$

This means that maximum $\tau$ occurs at neutral axis.

$$\tau_{max} \text{ at neutral axis} = \frac{V}{I}\frac{1}{2}\frac{d^2}{4} = \frac{1}{2}\frac{V}{\frac{bd^3}{12}}\frac{d^2}{4}$$

$$\tau_{max} \text{ at neutral axis} = \frac{3}{2}\frac{V}{bd}$$

bd is the area of the cross-section

Average Shear stress $= \tau_{ave} = \dfrac{V}{bd}$

Hence $\tau_{max}$ at neutral axis $= \dfrac{3}{2}\tau_{ave}$