UNIT-III UNSYMMETRICAL SECTIONS

Method for finding Bending Stress in Unsymmetrical Bending

1. **Find C.G. of the given section**
2. **Determine I_{xx}, I_{yy}, I_{xy} of the given section**
3. **Calculate value of θ from** $tan2\theta = \frac{2I_{xy}}{I_{yy} - I_{xx}}$
4. **Find values of I_{UU} and I_{VV}**
5. **Find M and its components**
6. **Find resultant bending stress**

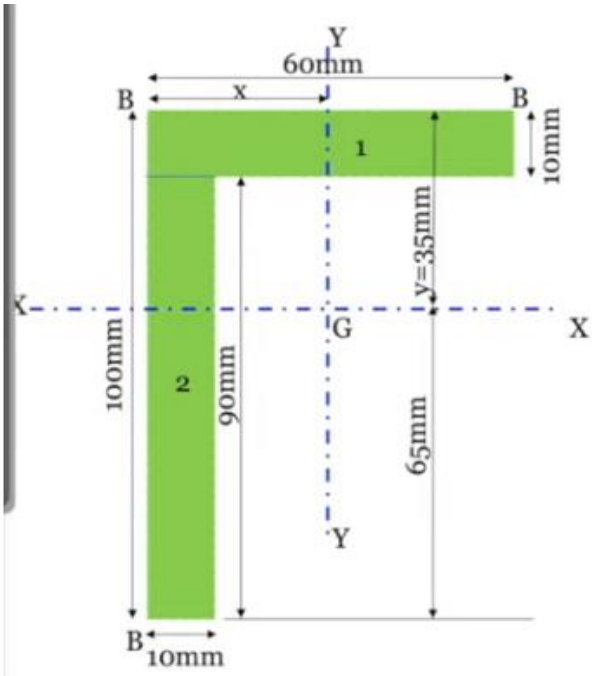


Fig. shows an unequal angle of dimensions 100mm by 60mm and 10mm thick. Determine:
(i) Position of principal axes and
(ii) Magnitude of the principal moments of inertia for the given angle.

Calculate C.G for the angle

$A_1 = 60 \times 10 = 600\ mm^2$

$A_2 = (100-10) \times 10 = 900\ mm^2$

Let (x_1, y_1) & (x_2, y_2) be the coordinates for ① & ② respectively

$x_1 = \frac{60}{2} = 30\ mm, \quad y_1 = \frac{10}{2} = 5\ mm$

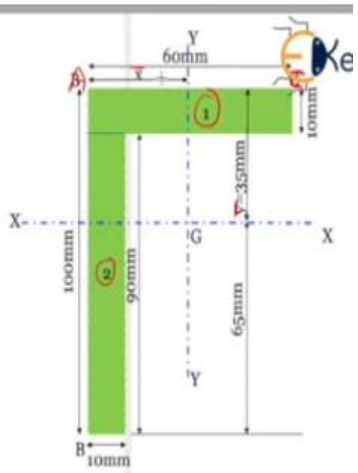
$x_2 = \frac{10}{2} = 5\ mm, \quad y_2 = 10 + \frac{90}{2} = 55\ mm$

$\bar{x} = \frac{A_1 x_1 + A_2 x_2}{A_1 + A_2} = \frac{600 \times 3 + 900 \times 5}{600 + 900}$

$\bar{x} = 15\ mm$

$\bar{y} = \frac{A_1 y_1 + A_2 y_2}{A_1 + A_2} = \frac{600 \times 5 + 900 \times 55}{600 + 900}$

$\bar{y} = 35\ mm$



$I_{xx} = \frac{60 \times 10^3}{12} + (60 \times 10) \times \left(\bar{y} - \frac{10}{2}\right)^2 + \frac{10 \times 90^3}{12} + \underbrace{10 \times 90 \times (65-45)^2}_{A}$

$I_{xx} = 1512500\ mm^4$

$I_{yy} = \frac{90 \times 10^3}{12} + 90 \times 10 \times (\bar{x} - 5)^2 + \frac{10 \times 60^3}{12} + 10 \times 60 \times (30 - \bar{x})^2$

$= 412500\ mm^4$

$I_{xy} = A_1 h_1 k_1 + A_2 h_2 k_2$

$I_{xy} = 600 \times 15 \times 30 + 900 \times -10 \times -20$

$= 450000\ mm^4$

$\because k_1$ = Horizontal dist of CG of rectangle 1 from Y-Y axis

$= (30 - \bar{x}) = 30 - 15 = 15\ m$

h_1 = Vert. dist of CG_1 of rect ① from X-X

$= \bar{y} - 5 = 35 - 5 = 30\ mm$

$k_2 = \bar{x} - 5 = 15 - 5 = 10\ mm\ (-ve)$

$h_2 = 65 - 45 = 20\ mm$

$= -20\ mm$

i) Position of principal axes

$$\tan 2\theta = \frac{2 I_{xy}}{I_{yy} - I_{xx}}$$

$$= \frac{2 \times 450000}{412500 - 1512500} = -0.818$$

$$2\theta = \tan^{-1}(-0.818) = -39.28^\circ$$

$$= 180 - 39.28$$

$$= 140.72^\circ$$

$$\theta = 70.36^\circ$$

ii) Value of principal M

$$I_{UU} = \frac{I_{xx} + I_{yy}}{2} + \frac{I_{xx} - I_{yy}}{2} \sec\theta$$

$$= \frac{1512500 + 412500}{2} +$$

$$\frac{1512500 - 412500}{2} \sec 140.$$

$$I_{UU} = 251905.6 \text{ mm}^4$$

$$I_{VV} = I_{XX} + I_{YY} - I_{UU}$$

$$= 1512500 + 412500 - 251906$$

$$I_{VV} = 1673094 \text{ mm}^4$$