# Paper

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Section A

4th semester

Subject advance mechanics of solids

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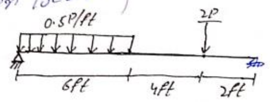
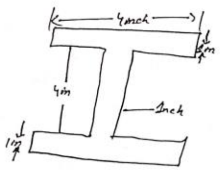
(1)(i)

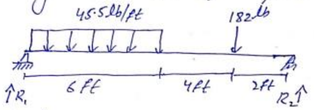
(Given Beam)




Solution:-

Putting the value of $P = 91$ so we have.




first to find unknown reaction at the support apply equilibrium equation.

$\Sigma F_x = 0$     ie  $R_3 = 0$

$\Sigma F_y = 0$

$R_1 + R_2 = ((45.5 \times 6) + 182)\, lb$

$\boxed{R_1 + R_2 = 455\, lb}$ — (1)

Next

$\Sigma M_A = 0$ (↻+ ↺−)

$R_2 \times 12 - 10 \times 182 - (45.5 \times 6) \times 3 = 0$

$12 R_2 = 1820 + 819$

$12 R_2 = 2639$

$R_2 = 2639/12$

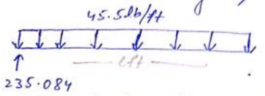
$\boxed{R_2 = 219.916}\, lb$

$R_1 + R_2 = 455\, lb$

$R_1 = 455 - 219.916 = 235.084\, lb$

$\boxed{R_1 = 235.084}\, lb$

Now shear force at change point of Beam.




. at 6ft.

Shear force at 6ft from support.

$\Sigma F_y = 0 \quad \uparrow + \downarrow -$

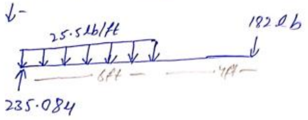
$R_1 = 235.084$

$235.084 - 45.5 \times 6 - V_{6ft} = 0$

$\boxed{V_{6ft} = -37.916 \, lb}$

Now shear force at 10ft

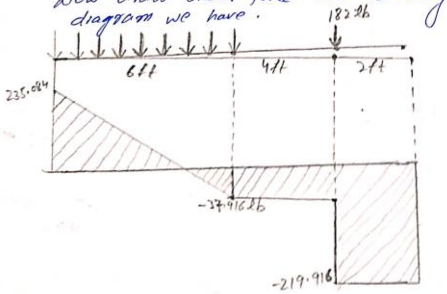
$\Sigma F_y = \quad \uparrow + \downarrow -$




$235.084 - 45.5 \times 6 - 182 - V_{10ft} = 0$

$\boxed{V_{10ft} = -219.916} \, lb$

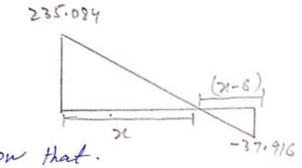
Now draw shear force and Bending moment diagram we have.



# Point of maximum Bending moment. Page 3

As we know that the point where Shear ~~po~~ force is maximum the bending ~~the~~ movement is maximum. So from point of zero shear corresponding point will have maximum bending movement.

From shear froce diagram we have.




we know that.

$$\frac{235.084}{x} = \frac{37.916}{6-x}$$

$\Rightarrow$ $(6-x)(235.084) = x(37.916)$

$\Rightarrow$ $1410.504 - 235.084x = 37.916x$

$\Rightarrow$ $1410.504 = 37.916x + 235.084x$

$\Rightarrow$ $1410.504 = 273x$

$\Rightarrow$ $x = \dfrac{1410.504}{273}$

$\Rightarrow$ $\boxed{x = 5.1667\ ft}$

Now determine the value of moment at 5.166ft.

$$M_{5.166} = -235.086 \times 5.1667 + (45.5 \times 5.166) \times \left(\frac{5.1667}{2}\right) = 0$$

$$M_{5.166} = -1{,}214.619 + 235.0848 \times 2.583$$

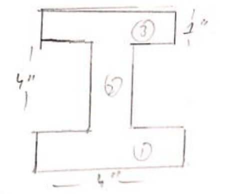
$$M_{5.166} = \cancel{1821.843}\ -1214.619 + 607.224$$

$$M_{5.166} = +607.395$$

For shear stress we have:

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

So first we determine moment of inertia I f0 the given section of Beam.




As the given figure is symmetrical along Both the axis.

So $\bar{x} = 4/2 = 2$ inch

$\bar{y} = 6/2 = 3$ inch

i-e $(\bar{x}, \bar{y}) = (2, 3)$

(center of gravity)

extreme left and Bottom

Area of point 1 = 4×1 inch.
Area of point 2 = 4×1 inch

" " 3 = 4×1 inch.

Moment of inertia about x axis (centroid I)
$I_{xx}$

Determine Distance b/w C.G of the whole section and corresponding parts let.
$G_1, G_2, G_3$ be in the centre of gravity of point 1 2 & 3 and $K_1, K_2, K_3$ be the distance b/w $\bar{y}$ and $y_1, y_2, y_3$ respectively so

$K_1 = \bar{y} - y_1 \Rightarrow 3 - 0.5 = 2.5$ inch.

$K_2 = \bar{y} - y_2 \Rightarrow 3 - 3 \Rightarrow 0$ inch

$K_3 = \bar{y} - y_3 \Rightarrow 3 - 0.5 = 2.5$ inch.

So

$$I_{xx} = \frac{b_1 h_1^3}{12} + a_1 K_1^2 + \frac{b_2 h_2^3}{12} + a_2 K_2^2 + \frac{b_3 h_3^3}{12} + a_3 K_3^2$$

$$I_{xx} = \frac{(4)(1)^3}{12} + 4(2.5)^2 + \frac{(1)(4)^3}{12} + a_2(0) + \frac{4(1)^3}{12} + 4(2.5)$$

$$I_{xx} = 4/12 + 25 + 64/12 + 4/12 + 25$$

$$I_{xx} = \frac{4 + 12(25) + 64 + 4 + 12(25)}{12}$$

$$\boxed{I_{xx} = 56 \text{ inch}^4}$$

Now

$$I_{yy} = \frac{b_1^3 h_1}{12} + \frac{b_2^3 h_2}{12} + \frac{b_3^3 h_3}{12}$$

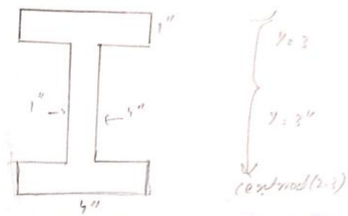
$$I_{yy} = \frac{(4)^3(1)}{12} + \frac{(1)^3(4)}{12} + \frac{(4)^3(1)}{12}$$

$$I_{yy} = \frac{64 + 4 + 64}{12}$$

$$\boxed{I_{yy} = 11 \text{ inch}^4}$$

Next find the shear stresses at various point we have.

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




i) shear stress at point "A" i.e At the top fiber

$$\tau = \frac{VQ}{Ib} \qquad V_{max} = 235.916 \text{ lb}$$

$$I = 67 \text{ in}^4$$

$$\text{so } \tau = \frac{235.916(0)}{67(4)}$$

Here A = 0 Beam in Area of the section exist above point A i.e $Q = A\bar{y}$, $0(\bar{y}) = 0$.

$$\boxed{\tau = 5.28 \text{ lb/in}^2}$$

ii) shear stress at point "B"

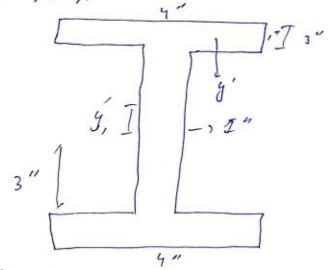
$$\tau = \frac{VQ}{Ib}$$

$$\tau = \frac{235.84 \times (4 \times 1)(3 - 0.5)}{67 \times 4}$$

$$\tau = 8.80 \text{ lb/in}^2$$

$$Q = A \cdot \bar{y}$$

Shear stress at point "C"
i.e at N.A




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

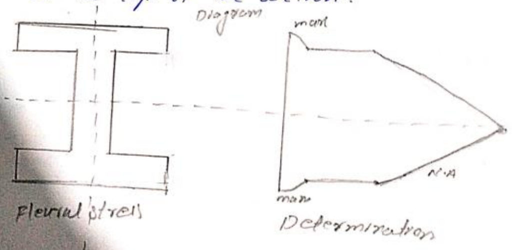
$\tau = \frac{238.84 \times \{4 \times 1 \times (3-0.5) + (1 \times 3)(2-1)\}}{67 \times 1}$

$\boxed{\tau = 35.24 \ lb/in^2}$

iv) Shear stress at point D and E will be the Same because of the symetry.

Note

The maximum shear stress value occur at the Neutral axis and minimum value at the top of the section.



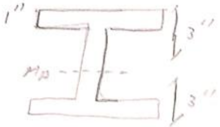
$$\delta = \frac{My}{I}$$

$$\delta = \frac{634.02 \times 3}{67}$$

$$\boxed{\delta = 28.38\, lb/in^2}$$

ii) Flexural stress at point "B"

$$\delta = \frac{My}{I}$$




$$\delta = \frac{634.02 \times (3-0.5)}{67}$$

$$\boxed{\delta = 23.65\, lb/in^2.}$$

iii) Flexural stress at point "C"

$$\delta = \frac{My}{I}$$

$$\delta = 634.02 \times (3-1)$$

$$\boxed{\delta = 18.92\, lb/in^2}.$$

iv) flexural stress at Neutral axis (N.A)

$$\delta = \frac{My}{I}$$

$$\delta = \frac{634.02 \times 0}{67}$$

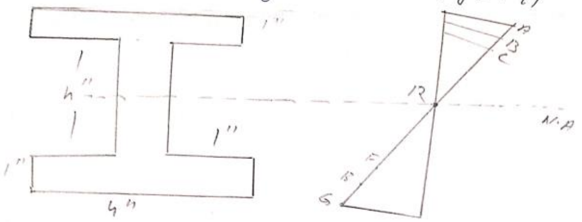
$$\boxed{\delta = 0\, lb/in}$$

Flexural stress value at point E.F and G remain the same because of symmetry. The upper portion above the N.A shows Tension and b/w the N.A show compression.

**Note**:- The flexural stress value is maximum at extreme top and bottom fiber at zero at N.A

Fleural stress diagram.






## Stress state

find stress state of a point element located 3ft from left support and 1 inch below from top fiber

flexural stress at point 'C'

$\sigma = 18.92$ psi

Shear strain at point "C"

$\tau =$ ~~35~~ $35.24$ psi

consider point "C" is a planner element


As the flexural stress is perpendicular to the cross section can be represented normal stress.

$\tau = 35.24$ is compressive because point "C" lies in compression zone of Beams cross section.

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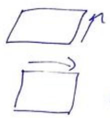
If point c lies below the centriod then stress would be tensile.



$\tau = 35.24\,psi$

$\sigma = 18.92\,psi$

Combine stress on 2d element.

Find the principle stress:

we have also find

$\sigma_x = 18.92$

$\sigma_y = 0$

$$\boxed{\tau_{x^2y} = 35.24.}$$

Principle stress eqations.

$$\sigma_{x,y} = \frac{\sigma_x + \sigma_y}{2} \pm \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{x^2y}}$$

$$\sigma_{x,y} = \frac{-18.92+0}{2} \pm \sqrt{\left(\frac{-18.92-0}{2}\right)^2 + (35.24)^2}$$

$$\sigma_{x,y} = -9.46 \pm \sqrt{+89.49 + 1241.857}$$

$$\sigma_{xy} = -9.46 \pm 36.487$$

$$\boxed{\sigma_{xy} = -9.46 - 36.487 = 45.947}$$

$$\boxed{\sigma_{xy} = -9.46 + 36.487 = 27.027}$$

or First ~~θp~~ find $\theta p$ = ?

$$\tan 2\theta p = \frac{\sigma_{xy}}{(\sigma_x - \sigma_y)/2}$$

$$\tan 2\theta p = \frac{35.24}{(-18.92-0)/2}$$

$$\tan 2\theta p = \frac{35.24}{-9.46}$$

$$\tan 2\theta p = -3.725$$

$$2\theta p = \tan^{-1}(-3.725)$$

$$\boxed{\theta p = -74.972}$$

put in general equations

$$\sigma max = \frac{-18.92+0}{2} + \frac{-18.92+0}{2} + \cos 2(-74.972) + 35.24 \sin 2(-74.972)$$

$$\sigma p max = -9.46 - 9.46 + 0.518 + 35.24 + (-1.9315)$$

$$\boxed{\sigma p max = -55.5735}$$

max in plane shear stress in this case

$$\tan 2\theta s = \frac{-(\sigma x - \sigma y)/2}{\sigma xy}$$

$$\tan 2\theta s = \frac{-(-18.92-0)/2}{35.24}$$

$$\tan 2\theta s = 0.2684$$

$$\theta s = \frac{\tan^{-1}(0.2684)}{2}$$

$$\theta s = \frac{15.024}{2}$$

$$\boxed{\theta s = 7.51 \text{ As}}$$

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Put in general equation

$$\tau_{x'y'} = -\left[\frac{\sigma_x - \sigma_y}{2}\right]\sin 2\theta + \tau_{xy}\cos 2\theta$$

$$\tau_{x'y'} = -\left(\frac{-18.92-0}{2}\right)\sin 2(7.51) + 35.24 \cos 2(7.51)$$

$$\tau_{x'y'} = 9.46(0.261) + 35.24(1.9828)$$

$$\tau_{x'y'} = 2.4690 + 69.875$$

$$\boxed{\tau_{x'y'} = 72.34406}$$

To Draw mohr's circle centre co-ordinate

$$(h, k) = \left(\frac{\sigma_x, \sigma_y}{2}, 0\right)$$

$$= \left(\frac{-18.92+0}{2}, 0\right)$$

$$= (-9.46, 0)$$

Radius of Mohr's circle

$$r = \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau^2_{xy}} = \sqrt{\left(\frac{18.92-0}{2}\right)^2 + (35.24)^2}$$

$$\boxed{r = 36.48}$$

scale
1 psi = 1 cm.