Name = M. Zohaib

ID# 7909

Section = A

Department = B.S civil Engineering

Paper = MOS 2

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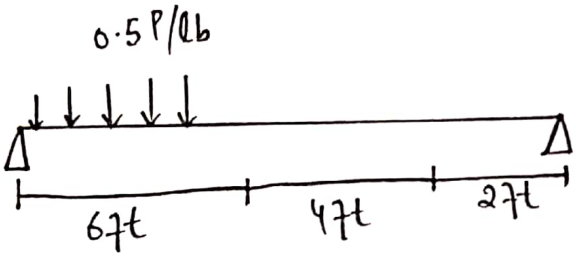
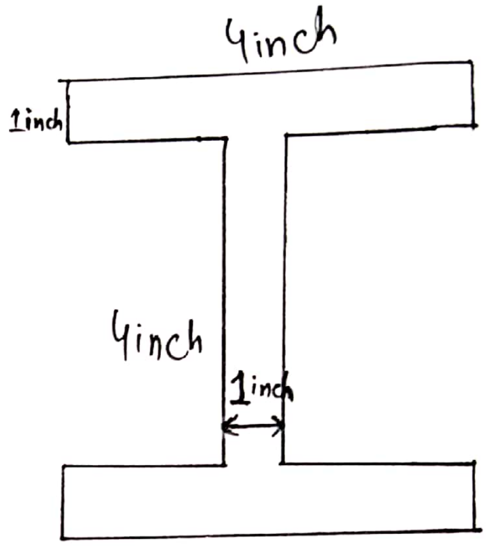
Question No 01

Ans:-

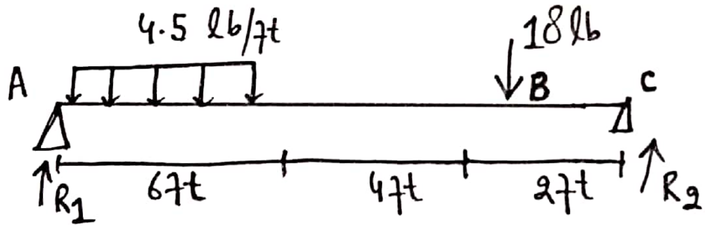
Given Beam





Note:- Put the value of $P = 09$

So we have



First to find unknown reaction at the support apply equilibrium equation-

$\Sigma F_x = 0$ i.e $R_3 = 0$

$\Sigma F_y = 0$ $\oplus \uparrow \downarrow \ominus$

$R_1 + R_2 = (4.5 \times 6)\, lb + 18\ lb$

$\boxed{R_1 + R_2 = 45\, lb}$

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Next

$\Sigma M_A = 0 \quad \circlearrowleft + \quad \circlearrowright -$

$R_2 \times 12 - 10 \times 18 - (27) \times 3 = 0$

$12R_2 = 180 + 81$

$\frac{\cancel{12}R_2}{\cancel{12}} = \frac{261}{\cancel{12}}$

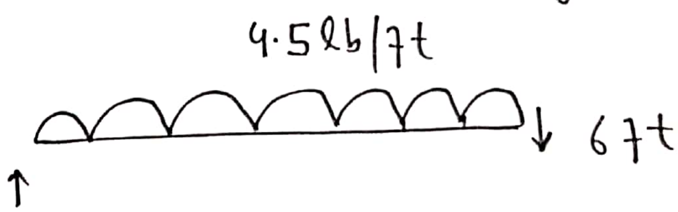
$\boxed{R_2 = 21.75}$

① $R_1 + R_2 = 45$

$\Rightarrow R_1 = 45 - 21.75$

$\Rightarrow \boxed{R_1 = 23.25}$

Now shear force at change Point of Beam



Shear at 6ft from support

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

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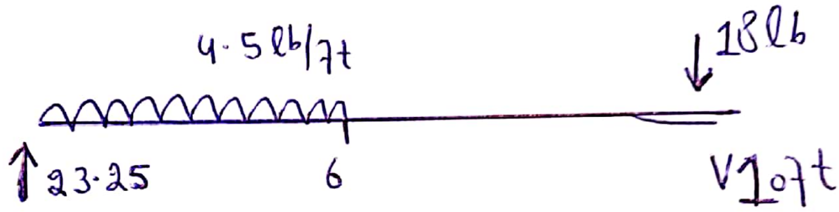
$$23.25 - 4.5 \times 6 - V_{6ft} = 0$$

$$\Rightarrow \boxed{V_{6ft} = -3.75}$$

Now shear force at 10ft

$\Sigma Fy = \uparrow \oplus \downarrow \ominus$



$$23.25 - 4.5 \times 6 - 18 - V_{10ft} = 0$$

$$\Rightarrow \boxed{V_{10ft} = -21.75}$$

Now draw Shear force and Bending moment diagram we have

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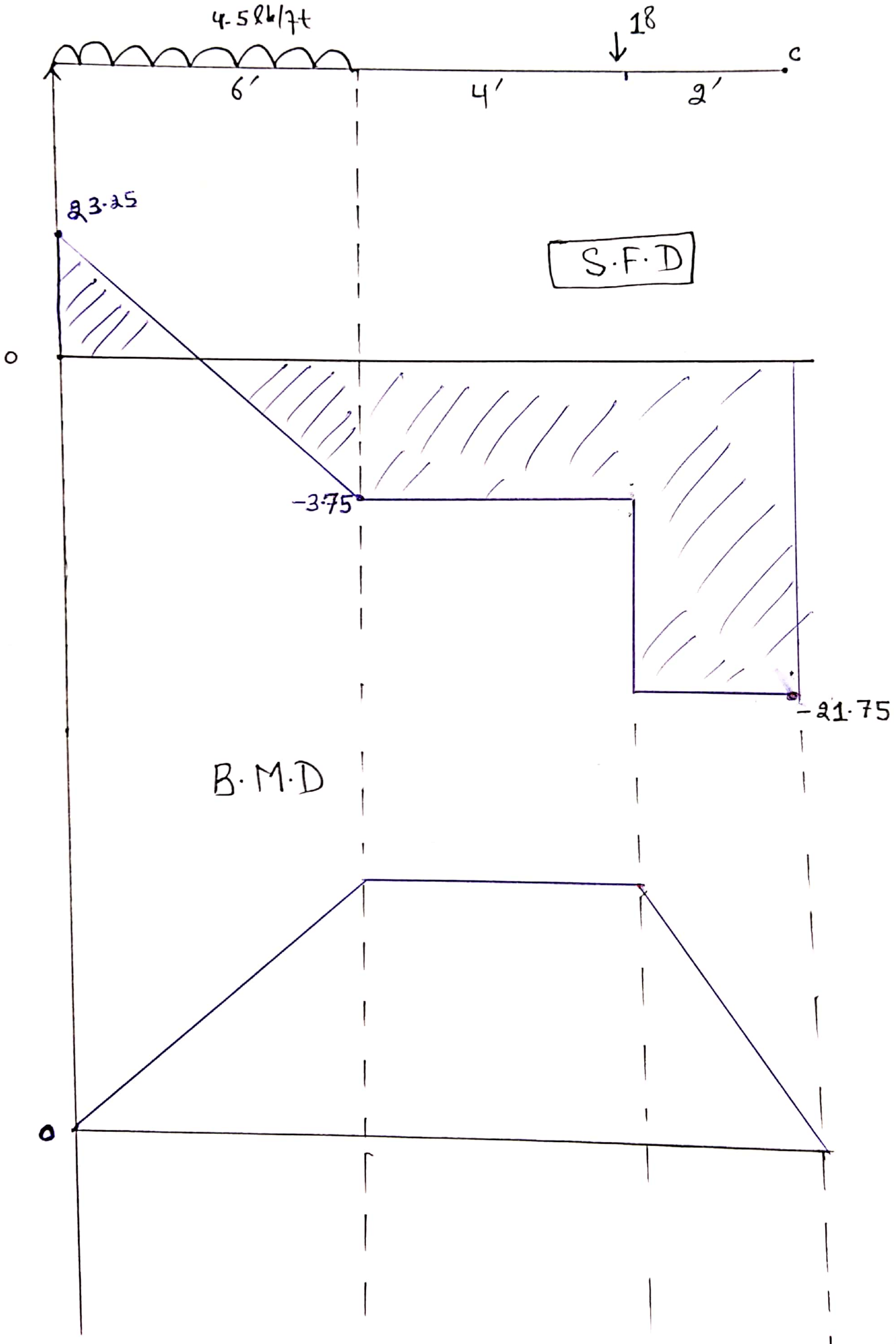

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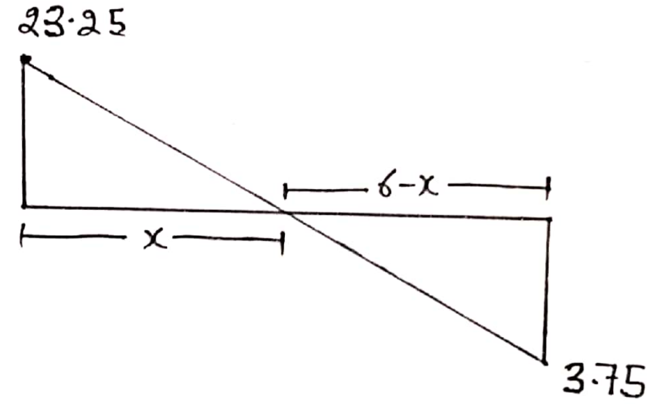
⇒ Point of Maximum Bending Moment

As we know that the Point where Shear force is maximum the bending moment is maximum So from Point of Zero Shear Corresponding Point will have maximum Bending Moment.

From Shear force diagram

We have



we know that

$$\frac{23.25}{x} = \frac{3.75}{6-x}$$

$$\Rightarrow (6-x)(23.25) = 3.75x$$

$$\Rightarrow 139.5 - 23.25x = 3.75x$$

$$\Rightarrow 139.5 = 3.75x + 23.25x$$

$$\Rightarrow \frac{\cancel{27}x}{\cancel{27}} = \frac{139.5}{27} \Rightarrow \boxed{5.166}$$

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Now determine the value of moment at 5.157ft

$$M_{5.157} - 23.25 \times 5.157 + (4.5 \times 5.157)\left(\frac{5.157}{2}\right) = 0$$

$$M_{5.157} - 119.90 + (23.2065)(2.5785) = 0$$

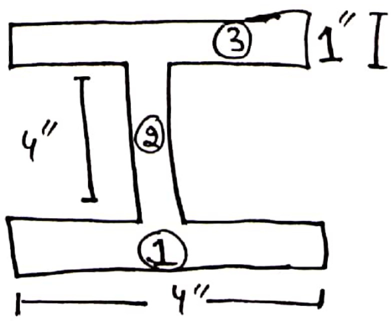
$$M_{5.157} = 119.90 - 59.837$$

$$\boxed{M_{5.157} = 60.063} \text{ lbft}$$

<u>For shear stress we have:-</u>

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

So first we determine moment of interia I of the given Section of Beam



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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 $= 4 \times 1 = 4 \text{ inch}^2$

Area of Point ② $= 4 \times 1 = 4 \text{ inch}^2$

Area of Point ③ $= 4 \times 1 = 4 \text{ inch}^2$

Moment of ~~inte~~ inertia about x-axis (centroid I) I_{xx}

Determine Distance between 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 and ③ and k_1, k_2, k_3 be the distance b/w $\bar{y}$ and y_1, y_2, y_3 Respectively.

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So

$k_1 = \bar{y} - y_1 \Rightarrow 3 - 0.5 = 2.5$ inch

$k_2 = \bar{y} - y_2 \Rightarrow 3 - 3 = 0$ inch

$k_3 = \bar{y} - y_3 \Rightarrow 3 - 0.5 = 2.5$ inch

So

$$I_{xx} = \frac{b_1 h_1^3}{12} + a_1 k_1^2 + \frac{b_2 h_2^3}{12} + a_2 k_2^2$$

$$+ \frac{b_3 h_3^3}{12} + a_3 k_3^2$$

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

$$+ \frac{4(1)^3}{12} + 4(2.5)$$

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

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

$$\boxed{I_{xx} = 56 \text{ inch}^2}$$

Now

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

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

$$I_{yy} = \frac{64 + 4 + 64}{12} = \boxed{11 \text{ inch}^2}$$

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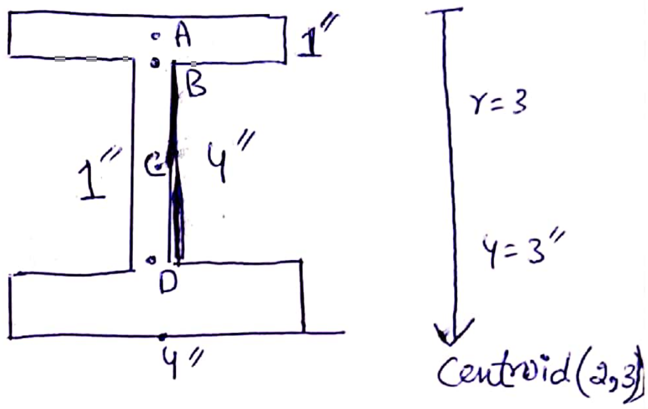
Next find the shear stresses at various Point

we have

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



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

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

$V_{max} = 21.75$

$I = 67\ in^2$

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

So $\tau = \frac{21.75(0)}{67(4)}$

$$\boxed{\tau = 0}$$

Here $A = 0$ Beam no Area of the Section exist above Point A

i.e $Q = A\bar{y}$, $0(\bar{y}) = 0$

(ii) Shear stress at Point "B"

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

$$\tau = \frac{(21.75)(4\times1)(3-0.5)}{67\times4}$$

$$\tau = \frac{217.5}{268.0}$$

$$\boxed{\tau = 0.811\ lbs/in^2}$$

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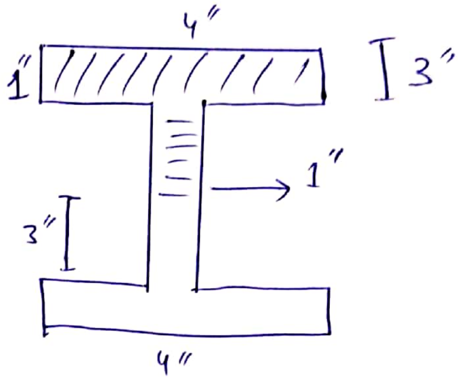
Shear stress at Point "C" i.e at N.A



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

$$\tau = \frac{\left[(21.75) \times (4 \times 1 \times (3-0.5) + (1 \times 2)(2-1)\right]}{67 \times 1}$$

$$\boxed{\tau = 3.276\ lb/in^2}$$

(iv) Shear stress at Point D and E will be the same because of the symetry.

Note:- The maximum shear stress value ~~will be~~ occour at the Neutral axis and minimum value at the top of the section.

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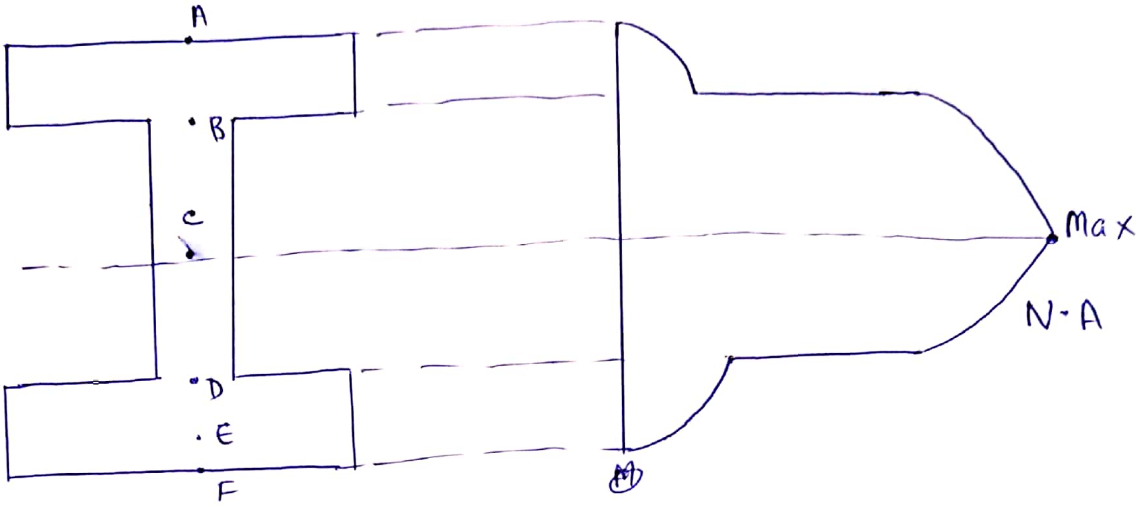
Shear stress Diagram



Flexural stress Determination

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

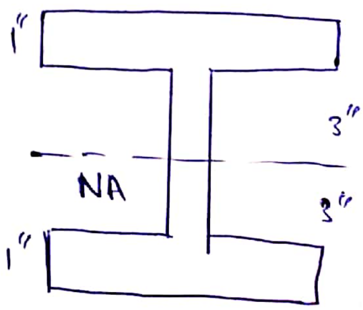
① Flexural stress at the top Fiber Point A

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

$$\delta = \frac{60.063 \times 3}{67}$$

$$\boxed{\delta = 2.689\ lb/in^2}$$

② Flexural stress at Point "B"



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

$$\delta = \frac{60.063 \times (3-0.5)}{67}$$

$\delta = 9.949\ lb...$

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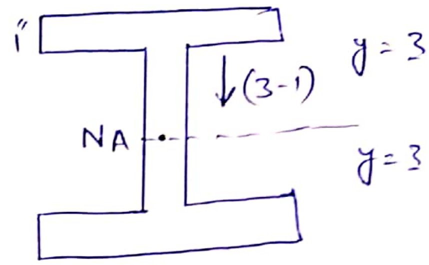
③ Flexural stress at Point "C"



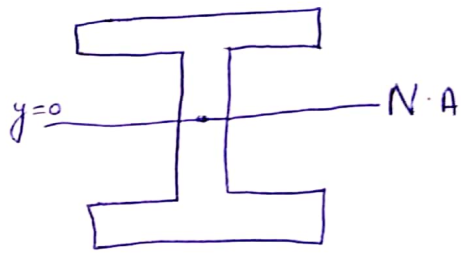
$$\delta = \frac{MY}{I}$$

$$\delta = \frac{60.063 \times (3-1)}{67}$$

$$\boxed{\delta = 1.792 \ lb/in^2}$$

④ Flexural stress at Neutral axis (N·A)

$$\delta = MY/I$$



$$\delta = \frac{60.063 \times 0}{67}$$

$$\boxed{\delta = 0 \ lb/in^2}$$

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 below the N·A show Compression

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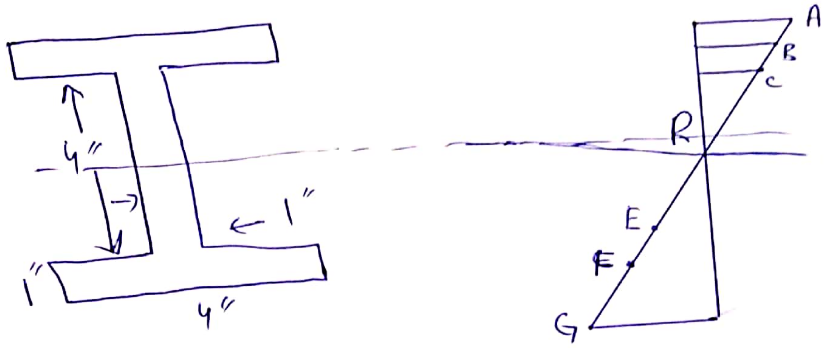
Flexural Stress diagram



Stress State:-

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

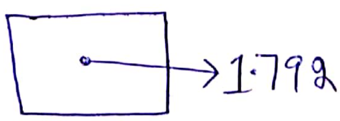
Flexural stress at Point "C"

$\delta = 1.792$ Psi

Shear stress at Point "C"

$\tau = 3.276$ lb/in2

Consider Point "C" is a Planner element



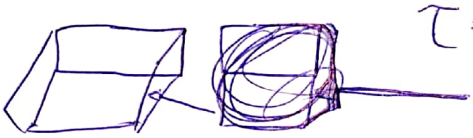
As the flexural stress is Perpendicular to the cross section Can be represented normal stress.

$\tau = 3.276$ Psi is comprective

Because Point "C" lies in compression Zone of Beam Cross section

If Point c lies below the Centroid the stress should be tensile.

$\tau = 3.276$ Psi



$\tau = 3.276$ Psi

$\sigma x = 1.792$ Psi

Combine stress on 2d element.

Find it Principle Stress:-

we have also find

$\sigma x = 1.792$

$\sigma y = 0$

$\tau_{xy} = 3.276$ Psi

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Principle stress equation

$$\sigma_{x,y} = \sigma x + \sigma y \pm \sqrt{\frac{(\sigma x - \sigma y)^2}{2} + \delta_{xy}^2}$$

$$\sigma_{x,y} = \frac{-1.792 + 0}{2} \pm \sqrt{\frac{(-1.792 - 0)^2}{2} + (3.276)^2}$$

$$\sigma_{x,y} = -0.896 \pm \sqrt{1.60 + 10.732}$$

$$= -0.896 \pm \sqrt{12.332}$$

$$\sigma_{x,y} = -0.896 \pm (3.51)$$

$$\sigma x = -0.896 - 3.51 = \boxed{4.407}$$

$$\sigma y = -0.896 + 3.51 = \boxed{2.614}$$

or First Find $\theta p = ?$

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

$$\tan 2\theta p = \frac{3.276}{\frac{(-1.792 - 0)}{2}}$$

$$\tan 2\theta p = \frac{3.276}{-0.896}$$

$$// = -3.65$$

$$2\theta p = \tan^{-1}(-3.65)$$

$$2\theta p = -74.67$$

$$\boxed{\theta p = -37.33}$$

Put in General equation

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$$\sigma_{max} = \frac{-1.792+0}{2} + \frac{-1.792+0}{2}$$

$$\cos 2(-37.33) + 3.276 \sin 2(-37.33)$$

$$\boxed{\sigma_p \, max = -43.362}$$

Max in plane shear stress in this case

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

$$\tan 2\theta_s = \frac{-(-1.792-0)/2}{3.276}$$

$$\tan 2\theta_s = \frac{0.896}{3.276}$$

$$2\theta_s = \tan^{-1}(0.273)$$

$$\frac{2\theta_s}{2} = \frac{15.26}{2}$$

$$\boxed{\theta_s = 7.63}$$

Put in these General equation

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

$$= -\left[\frac{-1.792-0}{2}\right] \sin 2(7.63) + 3.276 \cos 2(7.63)$$

$$= 0.238 + 24.98$$

$$\boxed{\tau_{x'y'} = 25.218}$$

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To Draw Mohr's Circle

Centre Co-ordinate

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

$$\Rightarrow \left(\frac{-1.792+0}{2}, 0\right)$$

$$\Rightarrow (-0.896, 0)$$

Radius of Mohr's Circle

$$r = \sqrt{\left(\frac{\sigma_x-\sigma_y}{2}\right)^2 + \tau^2_{xy}} = \sqrt{\left(\frac{-1.792-0}{2}\right)^2 + (3.276)^2}$$

$$= \sqrt{1.605 + 10.732}$$

$$= \sqrt{12.337}$$

$$\boxed{r = 3.51240}$$

Scale
1 psi = 1 cm