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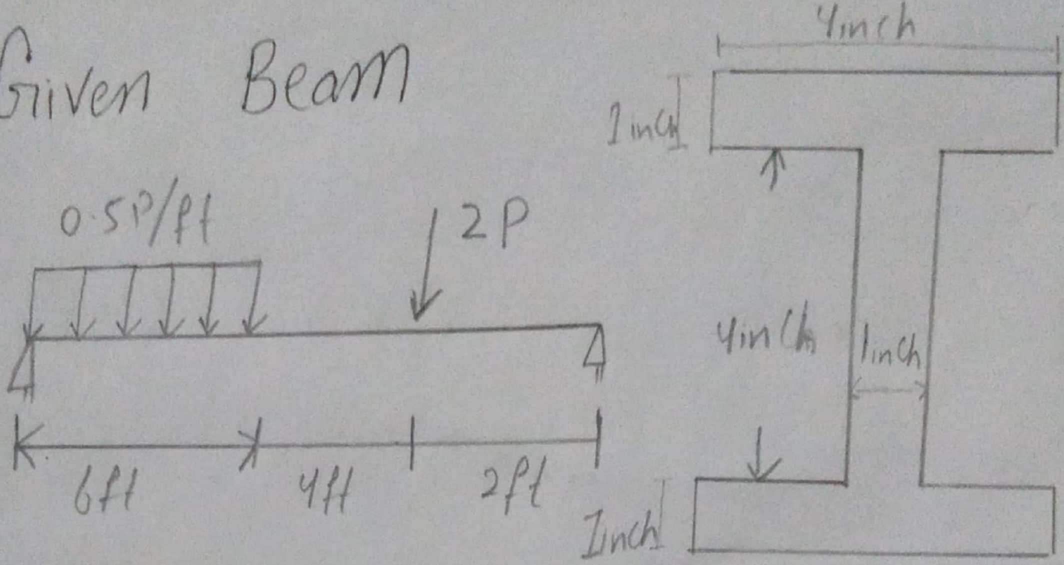
Section	B
Subject	Mos 2
Exam	Mid term
department	Civil
Semister	6th

1)

Question No 1

Ans :

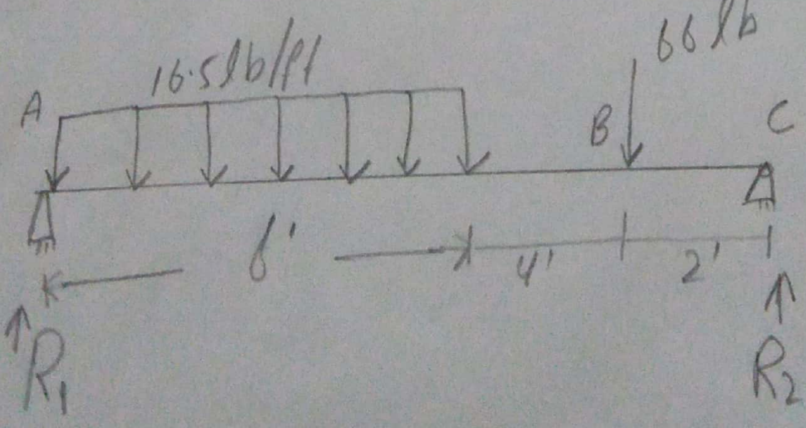
Given Beam



Note

Put the value of P= 33

So we have



2)

First to find the unknown reaction at the support Apply equilibrium equation

$\Sigma F_x = 0$ i.e $\boxed{R_3 = 0}$

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

$R_1 + R_2 = (16.5 \times 6)\,lb + 66\,lb$

$R_1 + R_2 = 99 + 66$

$R_1 + R_2 = 165 \rightarrow (1)$

Next

$\Sigma MA = 0$ $(+$ $-)$

$R_2 \times 12 - 10 \times 66 - (16.5 \times 6) \times 6/2 = 0$

$\Rightarrow 12R_2 = 660 + 297$

$\Rightarrow 12R_2 = 957\ lb\text{-}ft$

(3)

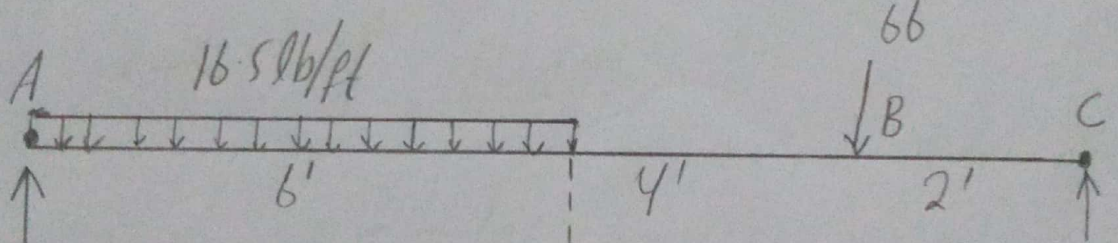
$\Rightarrow \boxed{R_2 = 79.75\ lb}$

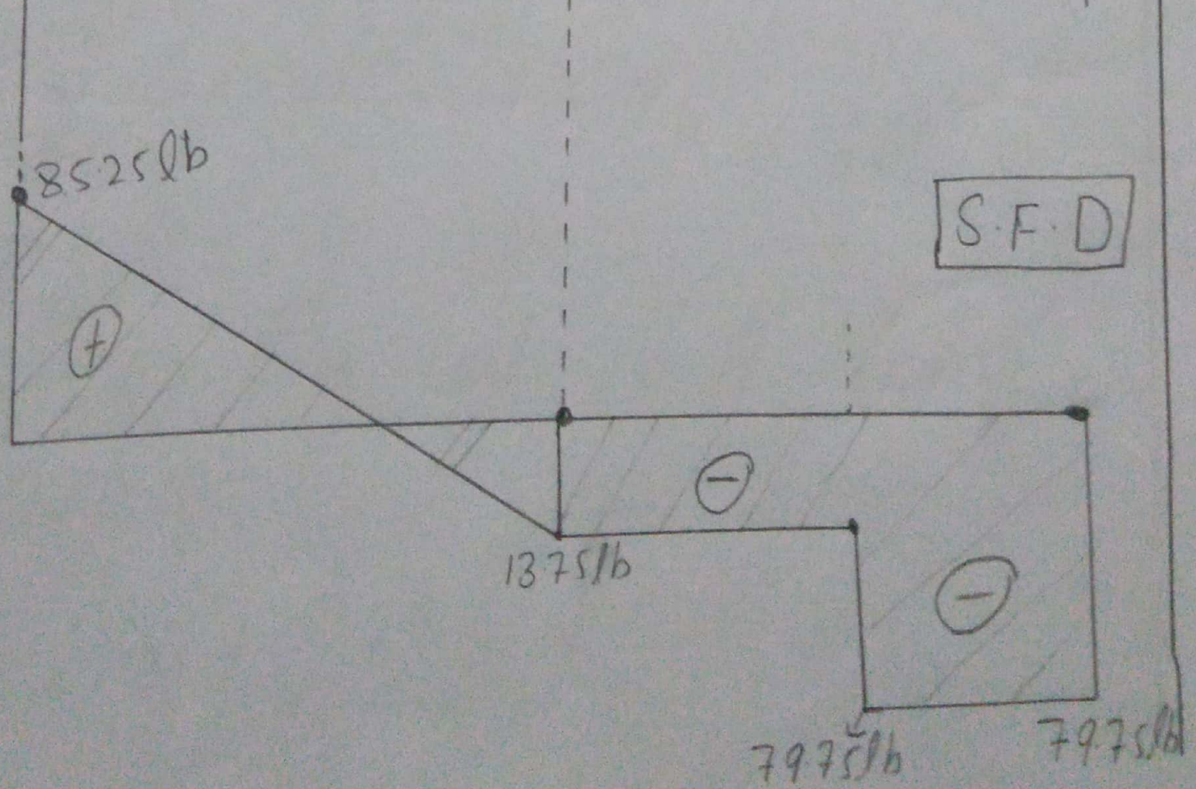
① $R_1 + R_2 = 165$

$\Rightarrow R_1 = 165 - R_2$

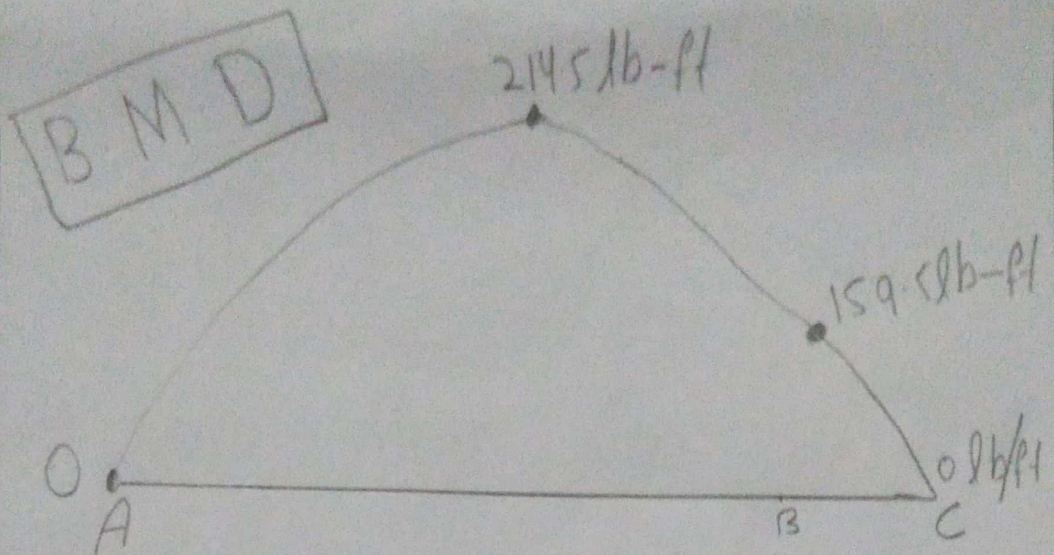
$\Rightarrow R_1 = 165 - 79.75 \Rightarrow \boxed{85.25\ lb}$

Now draw Shear force and Bending moment diagram we have

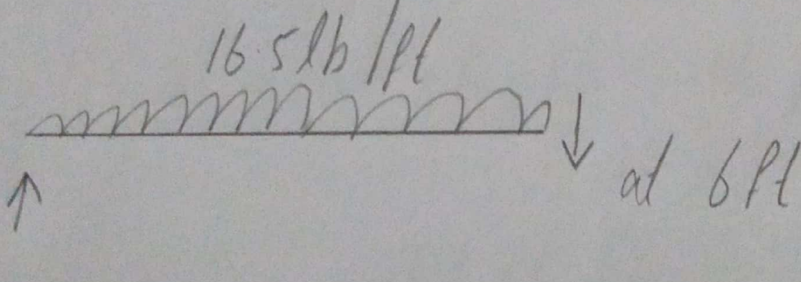




(4)



Now shear force at change point of Beam



Shear force at 6 ft from support

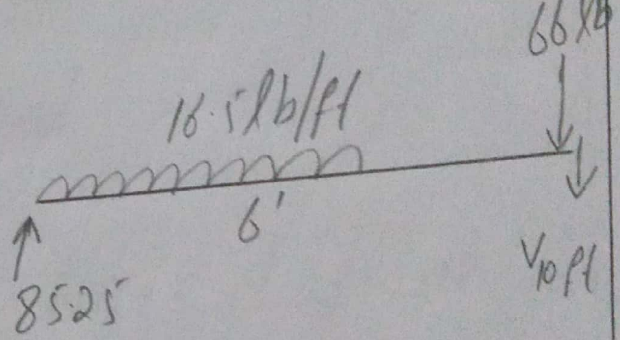
$\Sigma F_y = 0 \quad + \uparrow \quad \downarrow -$

$$85.25 - 16.5 \times 6 - V_{6ft} = 0$$

$$\Rightarrow V_{6ft} = -13.5 \text{ lb}$$

⊖ Now shear force at 10 ft

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



$$85.25 - 16.5 \times 6 - 66 - V_{10.ft} = 0$$

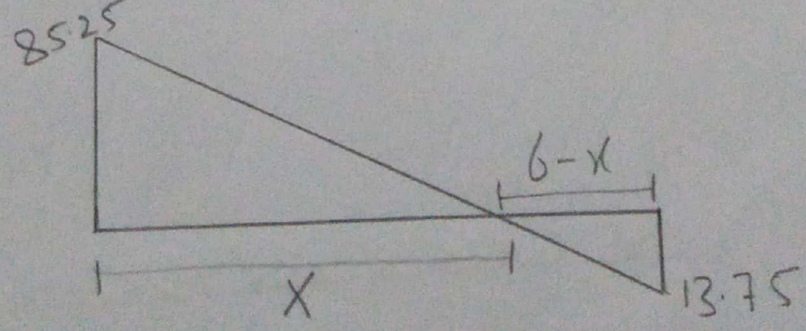
$$\Rightarrow V_{10 ft} = -79.75 \text{ lb}$$

(6)

⇒ Point of maximum Bending moment

As we know that the point where shear force is ~~max~~ minimum the bending moment is maximum so from point of zero shear corresponding point will have maximum Bending moment

From shear force diagram on page 3 we have



(7)

We know that

$$\frac{85.25}{x} = \frac{13.75}{6-x}$$

$\Rightarrow (6-x)85.25 = 13.75\,x$

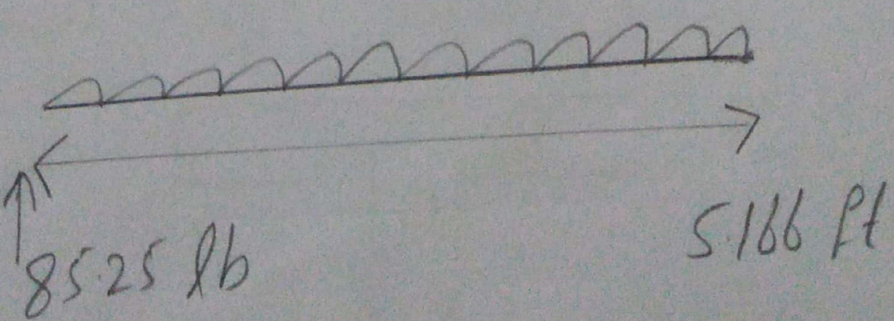
$\Rightarrow 511.5 - 85.25x = 13.75x$

$\Rightarrow 511.5 = 13.75x + 85.25x$

$\Rightarrow 99x = 511.5$

$\Rightarrow \boxed{x = 5.166\,ft}$

Now determine the value of moment at 5.166 ft



8)

$$M_{5.166} - 85.25 \times 5.166 + (16.5 \times 5.166) \times \left(\frac{5.166}{2}\right) = 0$$

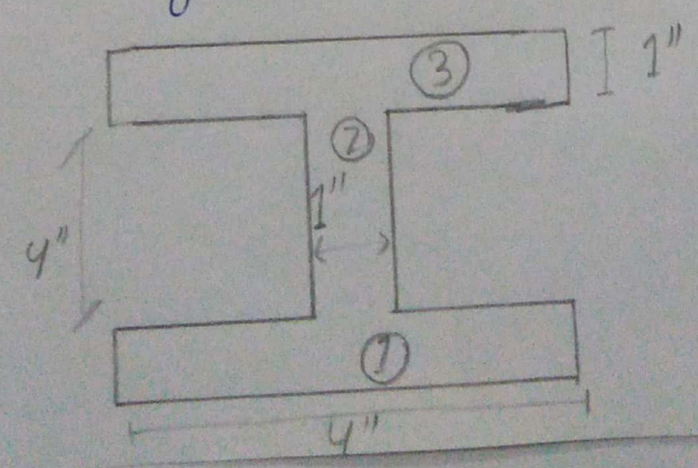
$$\Rightarrow M_{5.166} - 440.4015 + 215.50 = 0$$

$$\Rightarrow M_{5.166\,ft} = 224.899 \text{ lb-ft}$$

For shear stress we have :-

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

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



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As the given figure is symmetrical along bothe the axis

So $\bar{X} = 4/2 = 2$ inch in,

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

i.e $(\bar{X}, \bar{Y}) = (2, 3)$ (centre of gravity)

extreme left and Bottom

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

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

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

Moment of inertia about x-axis

(centroid I) I_{xx}

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10)

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

So

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

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

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

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

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

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

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

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

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

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

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

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(12)

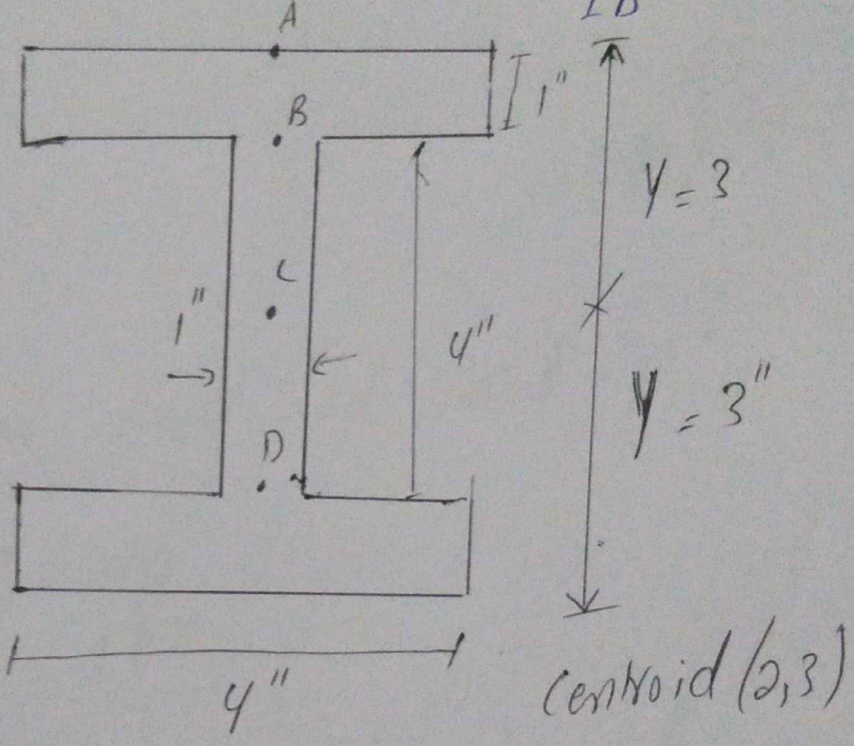
$$I_{yy} = \frac{64}{12} + \frac{4}{12} + \frac{64}{12}$$

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

⇒ Now Find the Shear Stress

We know that

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



① Shear stress at Point A

i.e At the top of Fibre

$V_{max} = 79.75$ lb

$I = 67$ in^4

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

$$Q = A\bar{Y}$$

(14)

So $\tau = \frac{79.75\,(0)}{67(4)}$

Here $A = 0$
Because no area of the section exist above
i.e. $Q = A\bar{Y} =$
$\Rightarrow 0(\bar{Y}) = 0$

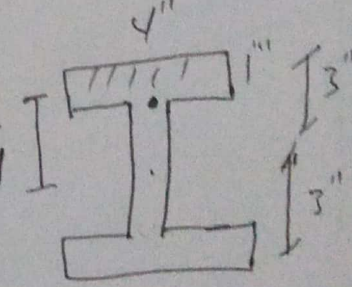
$$\boxed{\tau = 0}$$

(11)

Shear stress at Point "B"

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

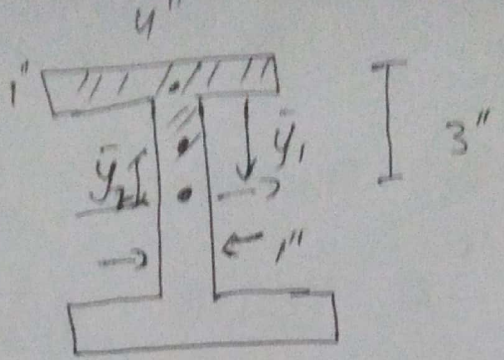
$$\tau = \frac{79.75 \times (4 \times 1)(3-0.5)}{67(4)}$$



$$\tau = 2.97\ lb/in^2$$

(15) (iii) Now shear force at point "c"

i.e at N.A



$$\tau = \frac{VQ}{It.}$$

$$\tau = \frac{79.75 \times [4 \times 1 \times (3-0.5) + (1 \times 2)(2-1)]}{67 \times 1}$$

$$\tau = \frac{79.75 \times 12}{67}$$

$$\tau = 14.28 \ lb/_{in^2}$$

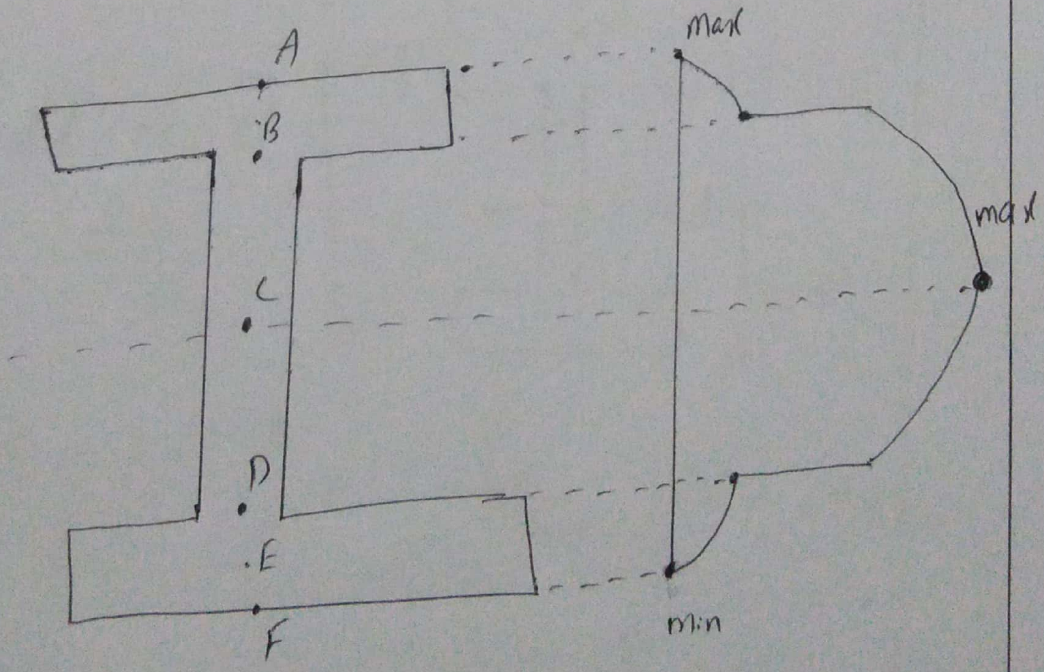
16 (iv)

Shear Stress at Point D and E will be the same.

Note:

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

Shear stress diagram



Flexural Stress determination:

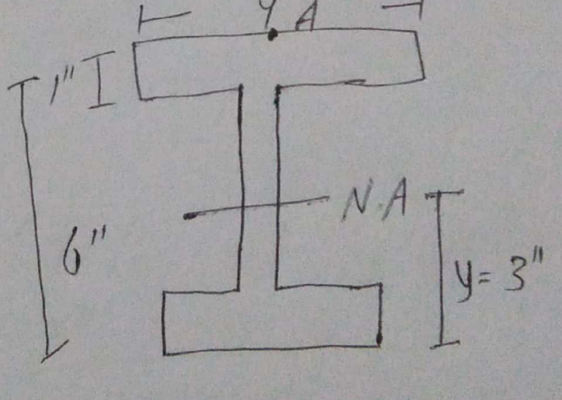
$$\sigma = \frac{MY}{I}$$

(10)

Flexural Stress at the top at point "A"

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

$$\sigma = \frac{224.899(3)}{67}$$



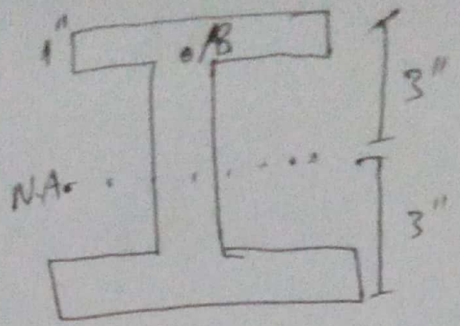
$$\sigma = 10.07\ lb/in^2$$

$M_{max} = 224.899$

18)

(2)

Flexural Stress at Point B



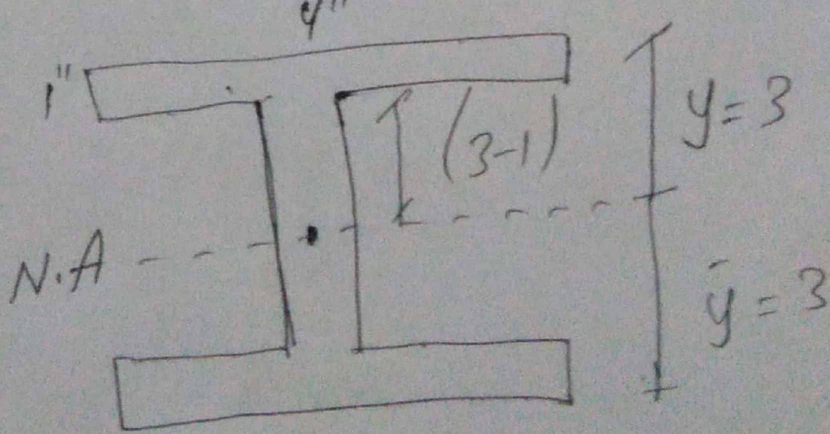
$$\sigma = \frac{My}{I}$$

$$\sigma = \frac{224.899 \times (3 - 0.5)}{67}$$

$$\sigma = 839\ lb/in^2$$

(III)

Flexure Stress at Point C



(19)

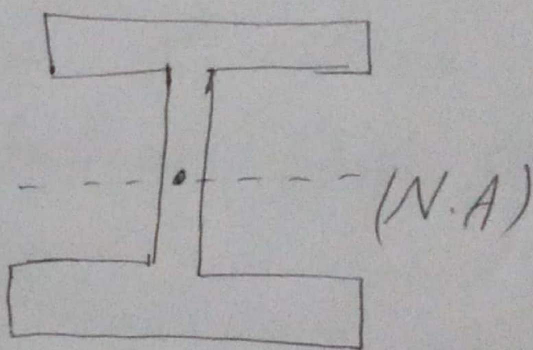
$$\sigma = \frac{MY}{I}$$

$$\sigma = \frac{224.899 \times (3-1)}{67}$$

$$\sigma = 6.71 \ lb/in^2$$

(iv)

Flexure stress at neutral axis (N.A)



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

$$\sigma = \frac{224.899 \times 0}{67}$$

$$\sigma = 0 \ lb/in^2$$

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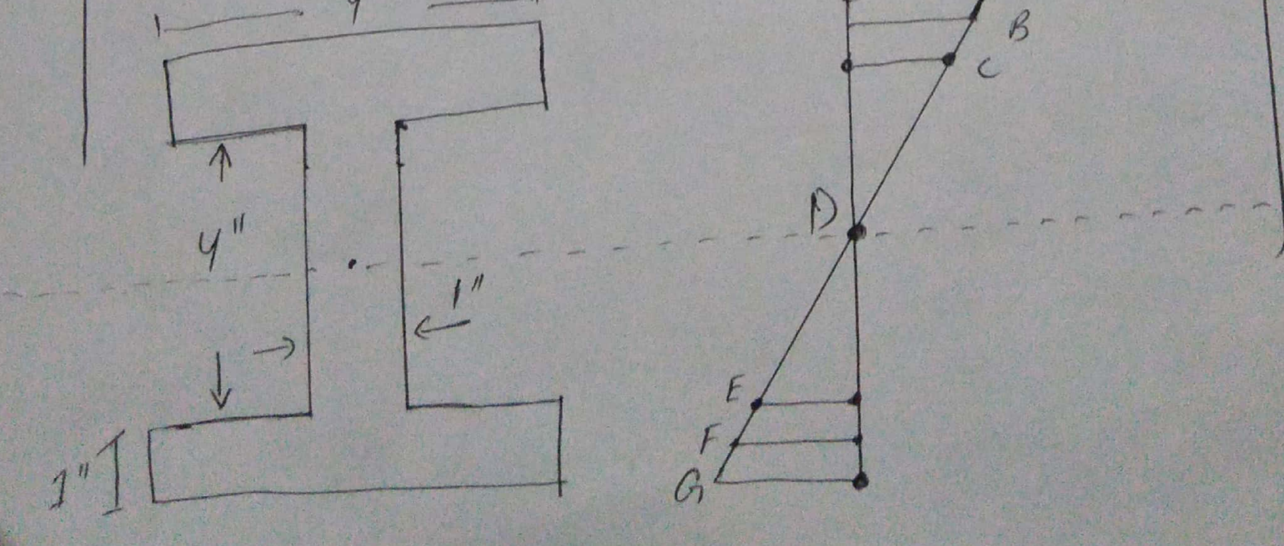
Flexure stress value at point E, F and g remain the same because of symmetry the upper portion above the N.A show tension and below the N.A shown compression.

Note

The flexure stress value is maximum at extreme top and bottom fibre at zero at N.A.

Flexure stress diagram.



Stress State :

Find stress state of a point e element located 3ft from left support and 2inch below from top fibre.

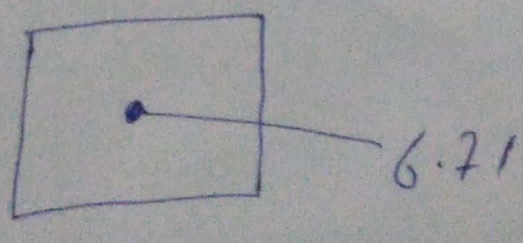
Flexural stress at point "C"

$\sigma = 6.71$ psi

Shear stress at point "C"

$\tau = 14.28$ psi

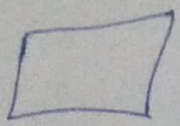
Consider point "C" is a planner element



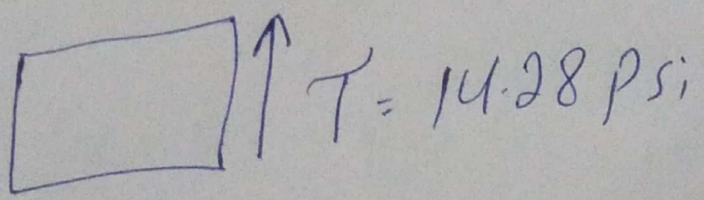
As the flexure stress is perpendicular to the cross section can be represented normal stress

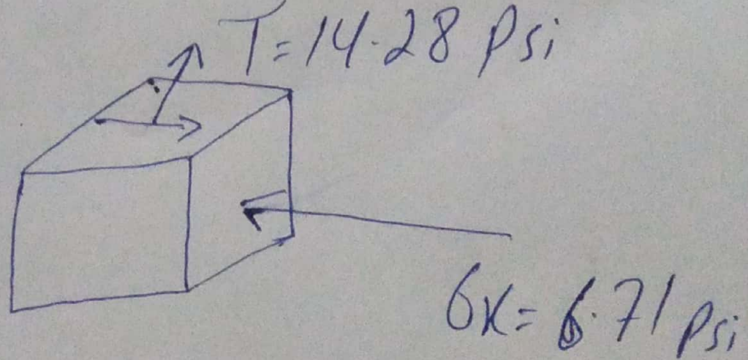
T = 14.28 Psi is compressive

Because point "C" lies in compression zone of Beam cross Section



If point C lies below the centroid then stress would be tensile.





Combine stress on 2D element.

Find it principle stress

We have also find

σ:

$\sigma_x = 6.71$

$\sigma_y = 0$

$\tau_{x^2 y} = 14.28$

Principle stress equation.

$$\sigma_{1,2} = \frac{\sigma_x + \sigma_y}{2} \pm \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{x^2 y}}$$

$$\sigma_{1,2} = \frac{-6.71 + 0}{2} \pm \sqrt{\left(\frac{-6.71 - 0}{2}\right)^2 + (14.28)^2}$$

$$\sigma_{1,2} = -3.355 \pm \sqrt{11.25 + 203.91}$$

$$\sigma_{1,2} = -3.355 \pm 14.66$$

$$\sigma_y = \sigma_1 = -3.355 + 14.66 = 11.305$$

$$\sigma_x = \sigma_2 = -3.355 - 14.66 = -18.015$$

Or

First find $\theta_p = ?$

$$\tan 2\theta_p = \frac{\tau_{xy}}{(\sigma_x - \sigma_y)/2}$$

$$\tan 2\theta_p = \frac{14.28}{(-6.71 - 0)/2}$$

$$\tan 2\theta_p = -4.25$$

$$2\theta_p = \tan^{-1}(-4.25)$$

$$\boxed{\theta_p = -38.37}$$

Put in general equation

$$\sigma_{max} = \frac{-6.71 + 0}{2} + \frac{-6.71 + 0}{2} \cos 2(-38.37) + 14.28 \sin 2(-38.37)$$

$$\sigma_{P_{max}} = -3.355 - 3.355(0.2293)$$

$$\sigma_{P_{max}} = -3.355 - 0.7693 - 13.899$$

$$\boxed{\sigma_{P_{max}} = -18.1243} \qquad \boxed{\sigma_x = -6.71}$$

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Max in Plane Shear Stress

in this case

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

$$\tan 2\theta_s = \frac{-(-6.71 - 0)/2}{(14.28)}$$

$\tan 2\theta_s = \cancel{\theta}$

$\boxed{\theta_s = 6.67}$ Anti clock wise

Put in these general equation

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

$$\tau_{x'y'} = -\left(\frac{-6.71 - 0}{2}\right)\sin 2(6.67) +$$

$$14.28 \cos 2(6.67)$$

Scale:

$S_{xy} = 14.66$ Psi

Max in Plane Shear Stress.

To Draw Mohr's circle:

Centre co-ordinate

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

$$\Rightarrow \left(\frac{-6.71 + 0}{2}, 0\right)$$

$$\Rightarrow (-3.355, 0)$$

Radius of Mohr's circle.

$$r = \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + S_{xy}^2} = \sqrt{\left(\frac{-6.71 - 0}{2}\right)^2 + (14.28)^2}$$

$$\boxed{r = 215.1684}$$

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Scale:

1 psi = 1 cm

Mohr's Circle