4th samister

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Section:- A

Subject:- Mos-II

Teacher:- Engr. Sir SaQIB

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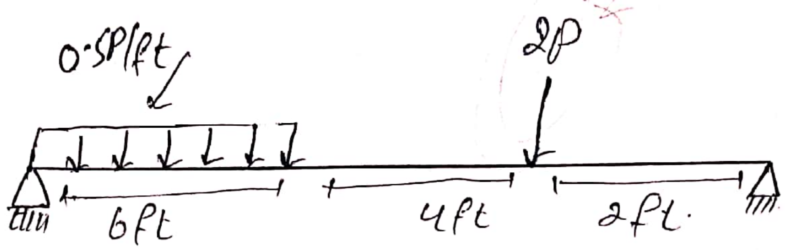
Question

Construct the mohr's circle diagram and find the principle stress and maximum in plane shear stress for the stress state of a point C located at the centre of uniform distributed load and 2 inches below the top of fiber of beam cross section shown in figure. However to construct the mohr's circle it is necessary to draw the shear and flexural stress variation diagram for maximum shear force and bending moment respectively. Compare the result obtained from the mohr's circle with the stress transformation equation

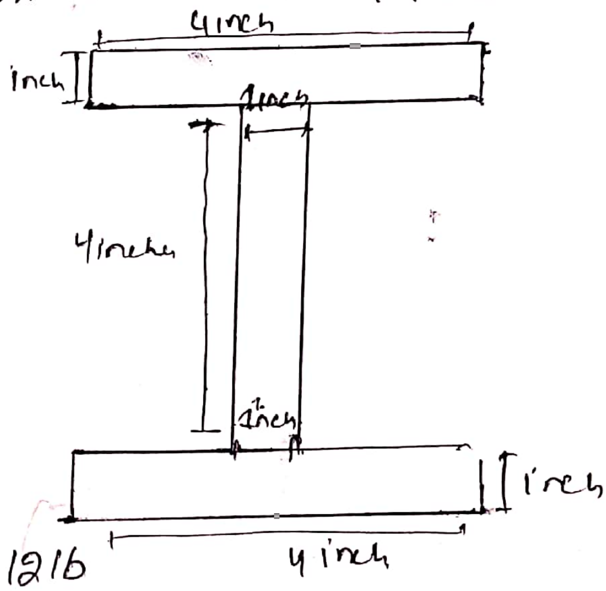
course P is the last two digits of class registration number in pounds



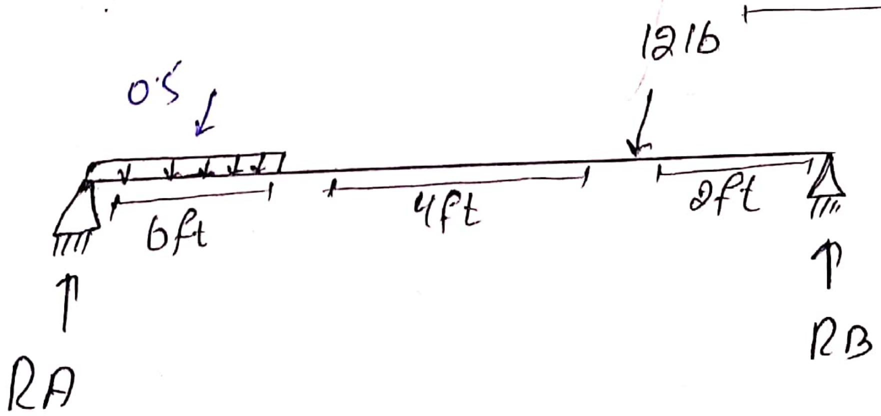
Here my class ragistration number is 7906

so $2P = 2 \times 06 = 12\,lb$

$0.5 \times 06 = 3\,lb/ft$



Free body diagram



Support Reactions

As we know that

$\sum F_y = 0 \quad \uparrow^{+} \downarrow^{-}$

$RA + RB = 15\ lb$ (2)

Now

$\sum M = 0 \circlearrowleft^{+} \curvearrowright^{-}$

$RB \times 12 - 12 \times 10 - 18 \times 3 = 0$

$12RB - 120 - 54 = 0$

$12RB = 120 + 54$

$\frac{\cancel{12}RB}{\cancel{12}} = \frac{174}{12}$

$\boxed{RB = 14.5\ lb}$

As

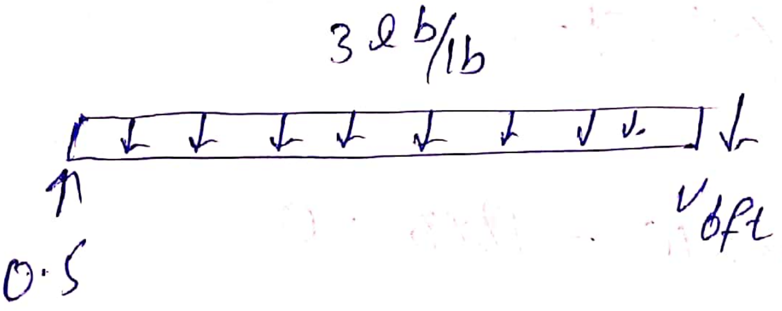
$RA + RB = 15$

$RA + 14.5 = 15$

$RA = 15 - 14.5$

$\boxed{RA = 0.5\ lb}$

Now Shear force at change point of beam.



So,

Shear force at 6ft from left Support

$\sum F_y = 0$ $\uparrow^{-}$ $\downarrow^{+}$

$V_{6ft} - 0.5 + 3\times 6 = 0$

$V_{6ft} - 0.5 + 18 = 0$

$V_{6f} = 0.5 - 18$

$V_{6f} = -17.5 lb$

Now Shear force at V_{10ft}

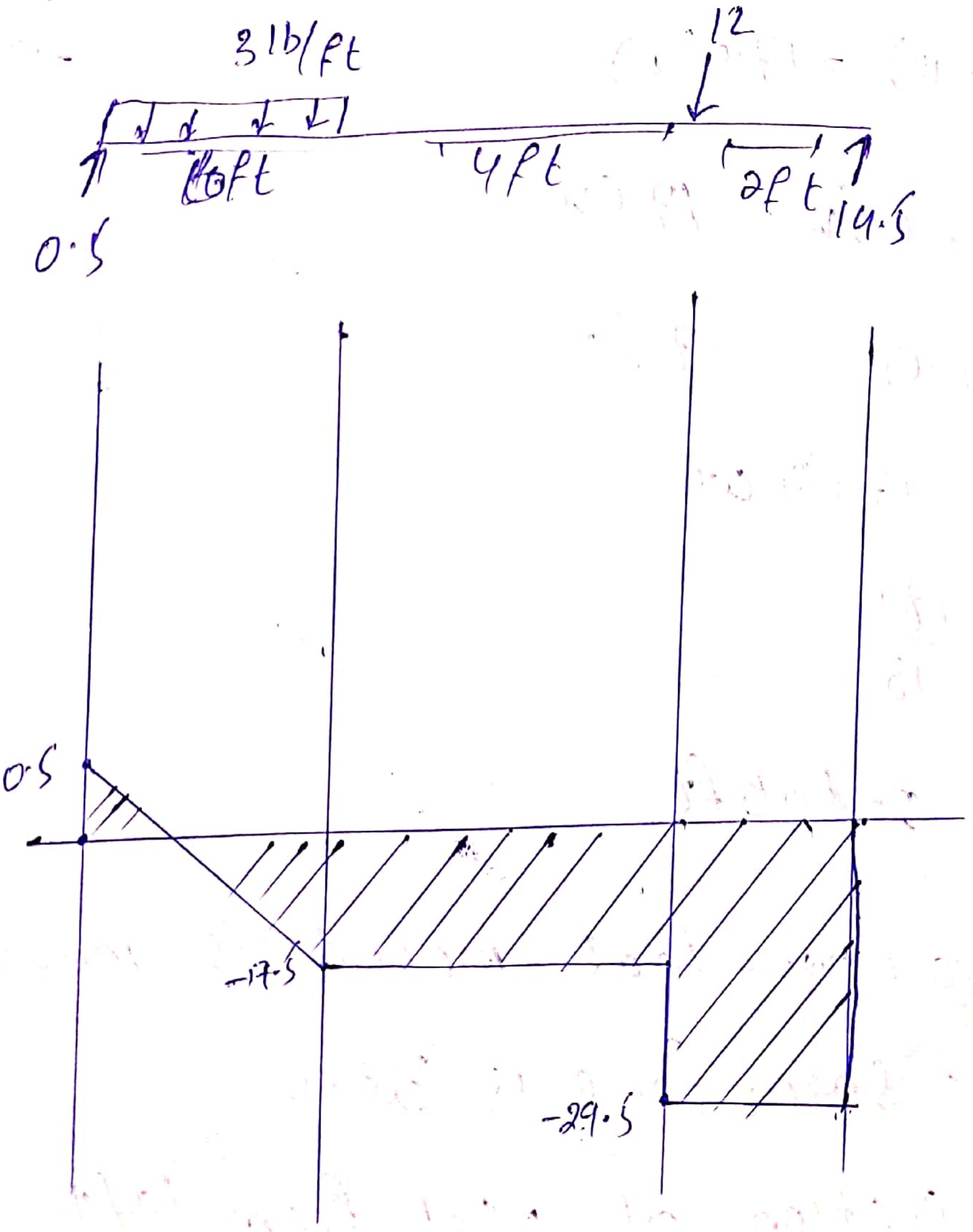
$\sum F_y = 0$ $\downarrow^{+}$

④

$$-0.5 + 18 + 12 + V_{10ft} = 0$$

$$V_{10ft} = 0.5 - 18 - 12$$

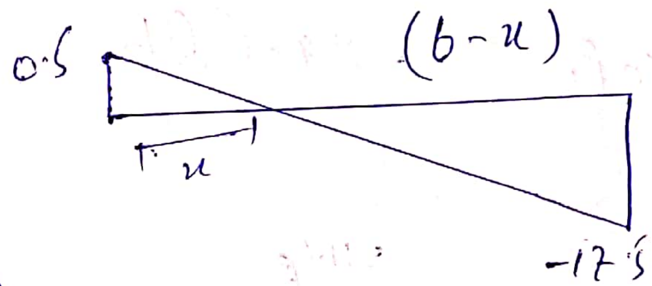
$$V_{10ft} = -29.5 \text{ lb}$$



Now moment at change point

Find zero shear point

$$\frac{0.5}{x} = \frac{17.5}{(6-x)}$$



$0.5(6-x) = 17.5(x)$

$0.5 \times 6 - 0.5x = 17.5x$

$3 - 0.5x = 17.5x$

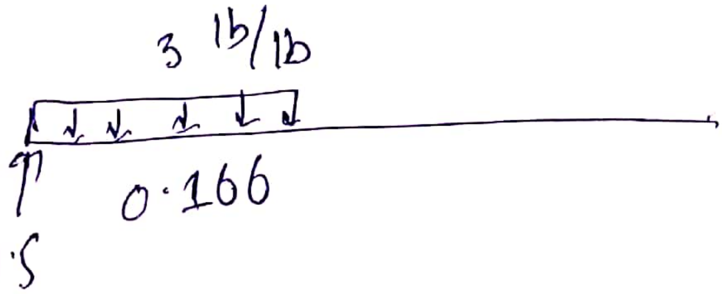
$3 = 17.5x + 0.5x$

$$\frac{3}{18} = \frac{18x}{18}$$

$x = 0.166$ ft

As we know that moment is maximum where shear force is zero

Take section of 0.166 from left support and find moment.



$$\sum M_{0.166} = 0 \quad +$$

$$M_{0.166} + 0.5 \times 0.166 - 18\left(\frac{0.166}{8}\right) = 0$$

$$M_{0.166} + 0.083 - 18(0.083) = 0$$

$$M_{0.166} + 0.083 - 1.494 = 0$$

$$M_{0.166} = 1.494 - 0.083$$

$$\boxed{M_{0.166} = 1.411\ lb\cdot ft}$$

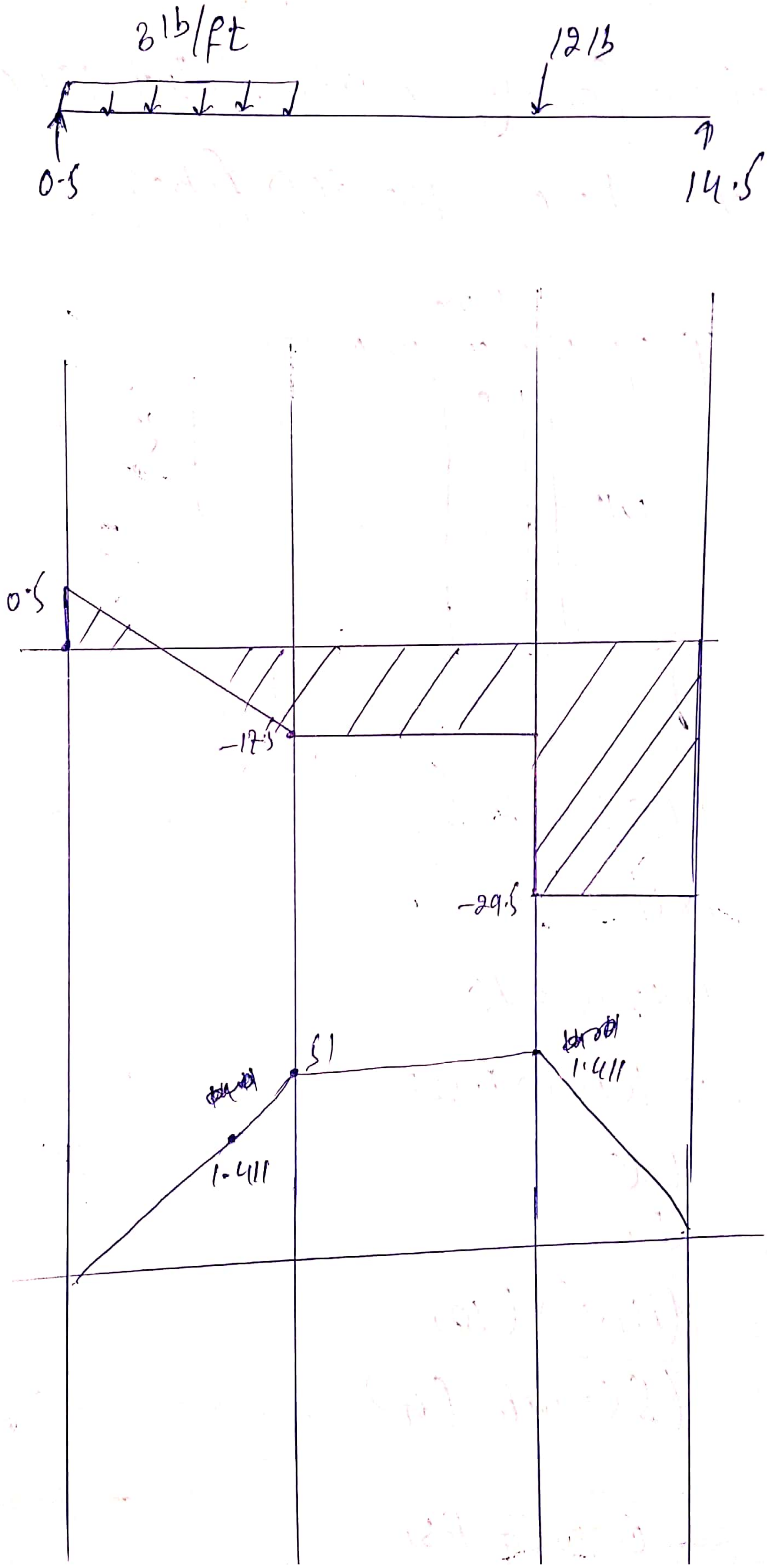
Now

$$\sum m = 0$$

$$M_{of} + 0.5 \times 6 - 3 \times 6 \times 3 = 0$$

$$\boxed{M_{of} = 51\ lb\cdot ft}$$

(7)



Now.

Shear Stress

As per question the maximum shear stress $\tau = \frac{VQ}{It}$ occurs where the maximum shear force lies in above diagram

max shear force is 1625 lb

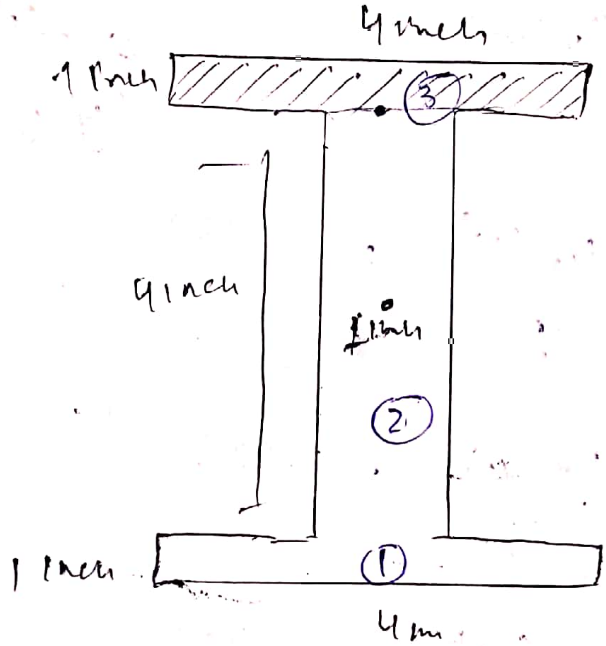
So,

To find the shear stress we have the following formula

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

we first find the moment of inertia

p.T.O.



As we know that to find Centroid we have the following formula

$$\bar{y} = \frac{A_1 y_1 + A_2 y_2 + A_3 y_3}{A_1 + A_2 + A_3}$$

$A_1 = 4 \times 1 = 4$

$A_2 = 4 \times 1 = 4$

$A_3 = 4 \times 1 = 4$

$$\bar{y} = \frac{4 \times 0.5 + 4 \times 3 + 4 \times 5.5}{4 + 4 + 4}$$

$\bar{y} = 3''$

Now moment of inertia.

NO	$A (in^2)$	$I_x (in)$	$d = (\bar{y} - y_1)$ $(\bar{y}-y_1)(\bar{y}-y_2)$
1	4	$\frac{4 \times (1)^3}{12} = 0.333$	
2	4	$\frac{1 \times (4)^3}{12} = 5.333$	
3	4.	$\frac{4 \times (1)^3}{12} = 0.333$	

(Now "d")

1. $d = (\bar{y} - y_1) = (3 - 0.5) = 2.5$
2. $d = (\bar{y} - y_2) = (3 - 3) = 0$
3. $d = (3 - 5.5) = -2.5$

(Now Ad^2)

1. $4 \times (2.5)^2 = 25$
2. $4 \times (0)^2 = 0$
3. $4 \times (-2.5)^2 = 25$

Now

$I_x = I_x + Ad^2$

① $0.333 + 25 = 25.333$

② $5.333 + 0 = 5.333$

③ $0.333 + 25 = 25.333$

Total

$I = I_{x_1} + I_{x_2} + I_3$

$I = 25.333 + 5.333 + 25.333$

$\boxed{I = 55.999 \text{ in}^4}$

Now shear stress

RA =

RB = 10

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

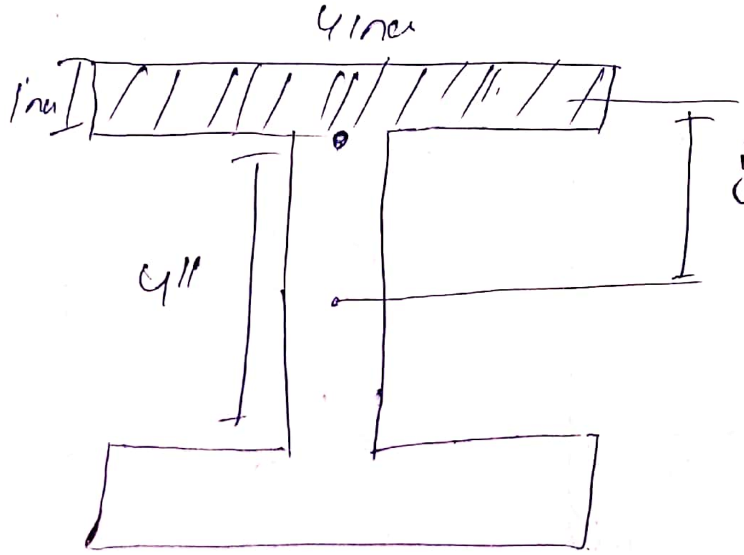
$V_{max} =$ ~~[illegible]~~ 14.5

$Q = \bar{y} A$

b = breath of that fiber

(9) (12)

Shear Stress at point "C" located at Centre of uniformly distributed load and Inch below the top fiber.



$\bar{y} = 2 + 0.5 = 2.5$

$A = 1 \times 4 = 4$

$Q = 4 \times 2.5 = 10$

As we know that

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

$$t = \frac{(14.5)(10)}{(55.996)(4)}$$

$$\boxed{t = 0.647} \text{ Psi}$$

Now Flexural Stree Analysis

$$6 = \frac{MY}{I}$$

where M is maximum moment in BMD

$$M = 51$$

$$\sigma = \frac{51 \times 2}{55.996}$$

$$\sigma = 1.82155 \text{ psi}$$

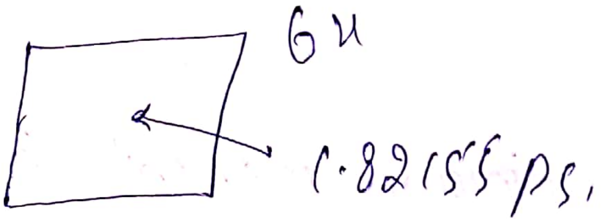
So, Shear Stress at point "C" is

$$t = \cancel{0.4}\ 0.647 \text{ psi}$$

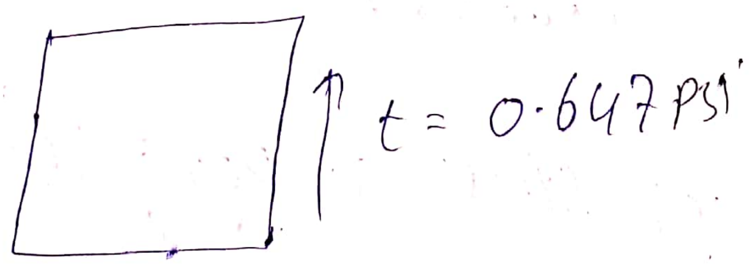
Flexural stree at point C

$$\sigma = 1.82155 \text{ psi}$$

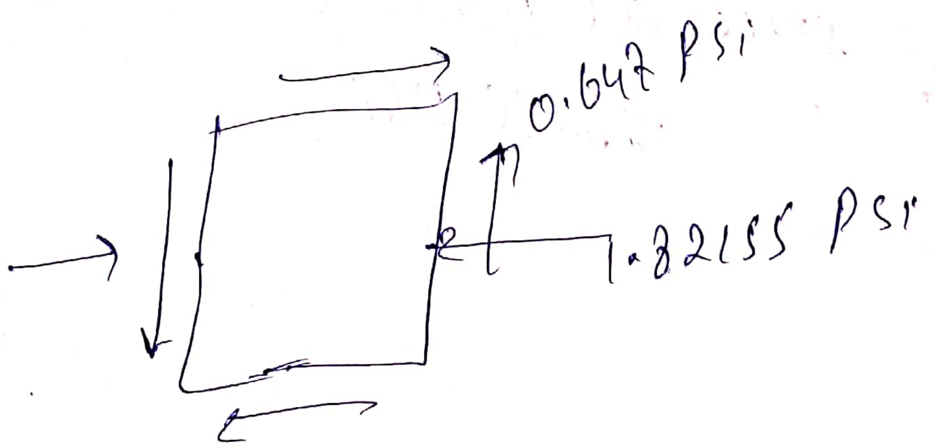
Now consider "C" is a planner element.



1.82155 psi is Compressive Becau point C lies in Compressive zone of Beam Now.



Combine stress on 2D elemt.

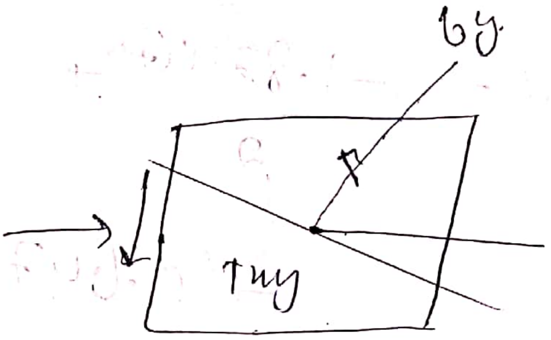


Scanned with CamScanner

Now we can find the stress state condition of point "C" at a degree of 30° clock wise orentation

Solution.

Given stress state →



$\sigma_x = -1.32155$ psi

$\sigma_y = 0$

$\tau_{xy} = 0.647$ psi

$\sigma_{x'} = ?$

$\sigma_{y'} = ?$

$\tau_{x'y'} = ?$

As we derived the following formula equation for stress transformation

$$\sigma_{x'} = \frac{\sigma_x + \sigma_y}{2} + \frac{\sigma_x - \sigma_y}{2}\cos 2\theta + \tau_{xy}\sin 2\theta$$

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

$$\sigma_{y'} = \frac{\sigma_x + \sigma_y}{2} - \frac{\sigma_x - \sigma_y}{2}\cos 2\theta - \tau_{xy}\sin 2\theta$$

For $\sigma_{x'}$

$$\sigma_{x'} = \frac{-1.82155+0}{2} + \frac{-1.82155-0}{2}\cos(2(-20)) + (0.647)\sin(2(-20))$$

$$\sigma_{x'} = -0.910 + 0.697 - 0.4158$$

$\sigma_{x'} = -2.0228$ psi Compression

For $\sigma_{y'}$

$$\sigma_{y'} = \frac{-1.82155+0}{2} - \frac{(-1.82155)-0}{2}\cos 2(-20) - (0.647)\sin 2(-20)$$

$$\sigma_{y'} = -0.910 + 0.697 + 0.4158$$

$\sigma_{y'} = 0.2028$ psi (Tension)

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

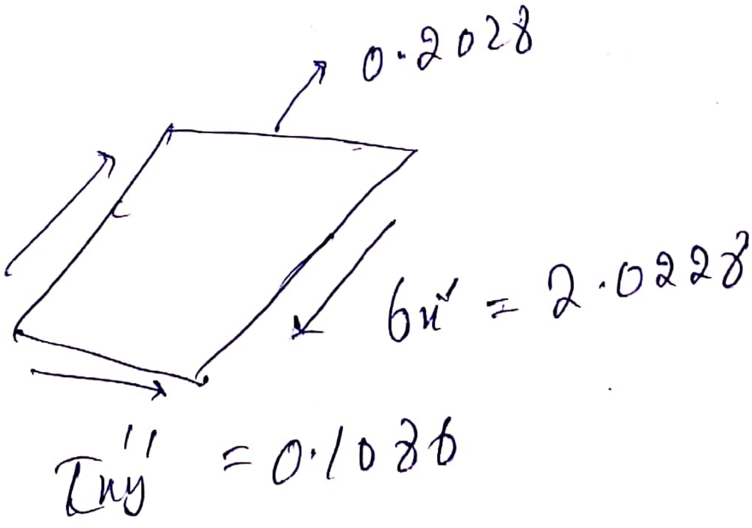
$$= -\frac{(-1.32155 - 0)}{2} \sin 2(-20)$$

$$+ 0.647 \cos 2(-20)$$

$$= -0.5354 + 0.694$$

$$\boxed{\tau_{x'y'} = 0.1036} \text{ psi}$$

Now the new stress state after the 20° clockwise rotation is



Find the principle stress

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

$$= \frac{-1.8215+0}{2} \pm \sqrt{\left(\frac{-1.82155-0}{2}\right)^2+(0.647)^2}$$

$$= -0.910 \pm \sqrt{0.8295+0.418}$$

$$= -0.900 \pm 1.1169$$

$$\sigma_y = \sigma_1 = -0.910 + 1.1169 = 0.2069$$

$$\sigma_x = \sigma_2 = -0.900 - 1.1169 = 1.89215$$

Now.

Max in plane shear stres

$$\tau_{xy} = \sqrt{\left(\frac{\sigma_x + \sigma_y}{2}\right)^2 + \tau_{xy}^2}$$

$$= \sqrt{\left(\frac{-1.82155 - 0}{2}\right)^2 + (0.647)^2}$$

$$= \sqrt{0.8295 + 0.418}$$

$$\boxed{\tau_{xy} = 1.1169 \text{ psi}}$$ main plane shear stress

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To Draw mohr's circle for the Given Problem

Solution

As we know that to draw the circle we need the Coordinates of circle as well as radius

The coordinates of circle can be find by this

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

Centre Coordinates

$$(h, k) = \left(-\frac{1.82155}{2}, 0\right)$$

$$= (-0.91077, 0)$$

Now,

Radius of mohr's circle

$$r = \sqrt{\left(\frac{\sigma_x + \sigma_y}{2}\right)^2 + \tau_{xy}^2}$$

$$r = \sqrt{\left(-\frac{1.82155}{2} - 0\right)^2 + (0.647)^2}$$

$$r = \sqrt{0.8295 + 0.418}$$

$\boxed{r = 1.1169}$