Subject: Mechanics of Solid-2.

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PAPER SOLVED

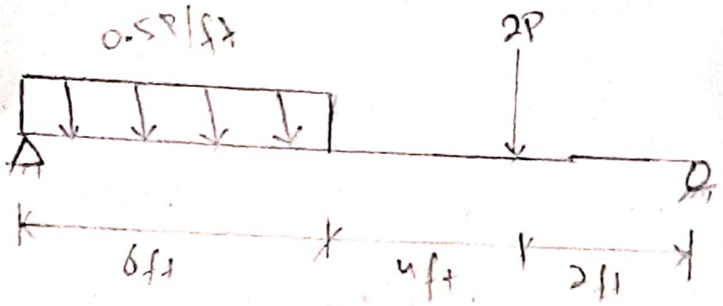
THANKS.

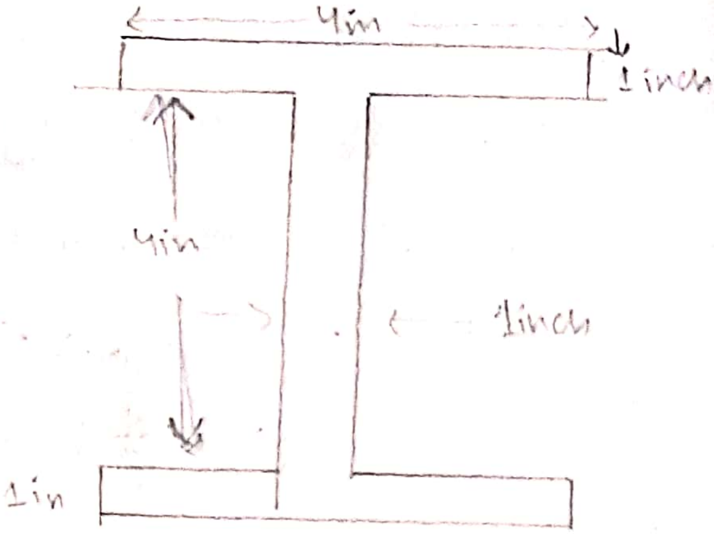
ID= 7889

QUESTION # 01

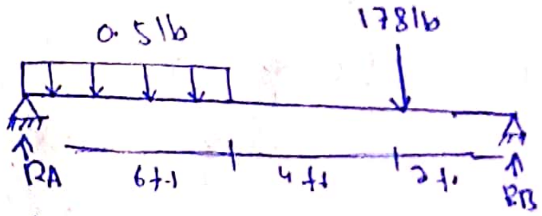
construct the Mohr's circle diagram and find the principle stress and maximum in plane shear stress for the stress state of a point "C" located at the center of uniformly distributed load and 1 inches below the top fiber of beam cross section shown in figure. However to construct the Mohr's circle it is neccessary to draw the shear stress and flexural stress variation diagram for maximum shear force and bending moment respectively compare the results obtained from the Mohr's circle with the stress transformation equations

Hint:- To calculate the stress in the beam cross-section the moment of inertia must be known. Where P is the last two digits of your class registration number in Pounds.





Free body diagram:



I.D = 7889

$2 \times 89 = 178$

Reaction

As we know

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

$$R_A + R_B = 0.5 + 178$$

$$\boxed{R_A + R_B = 178.5}$$

Now $\Sigma M = 0 \quad \overset{+}{\circlearrowright} \ \overset{-}{\circlearrowleft}$

$$R_B \times 178 - 178 \times 10 - 3 \times 3 = 0$$

$$178 R_B = 1780 + 9$$

$$\frac{178 R_B}{178} = \frac{1789}{178}$$

$$\boxed{R_B = 10.05}$$

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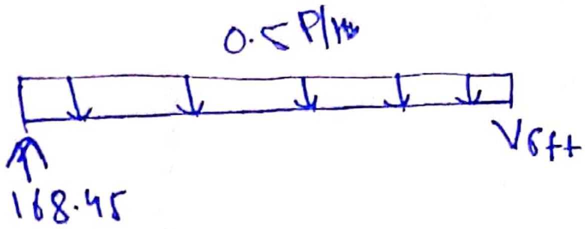
$R_A + R_B = 178.5$

$R_A = 178.5 - 10.05$

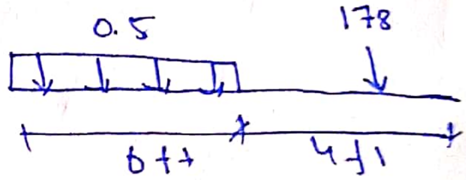
$\boxed{R_A = 168.45}$

Now shear force at change point of Beam



So, shear force at 6ft from left support

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



$+V_{6\,ft} - 168.45 + 0.5 \times 6 = 0$

$+V_{6ft} - 168.45 + 3 = 0$

$V_{6ft} - 168.45 - 3$

$\boxed{V_{6ft} = 165.45 \text{ lb}}$

Now again;

Shear force at V_{10ft}

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

$-168.45 + 3 + 178 + V_{10ft} = 0$

$V_{10ft} = 168.45 - 181$

$\boxed{V_{10ft} = -12.55}$

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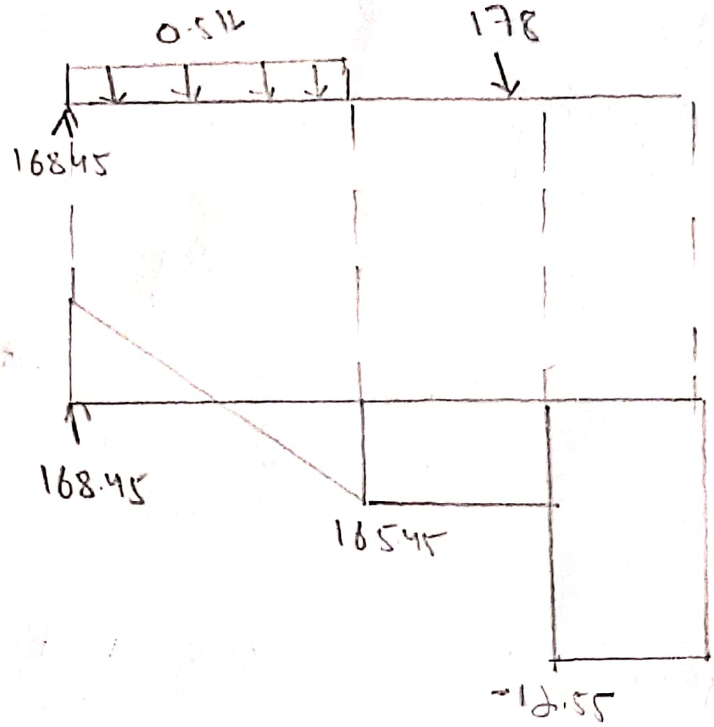
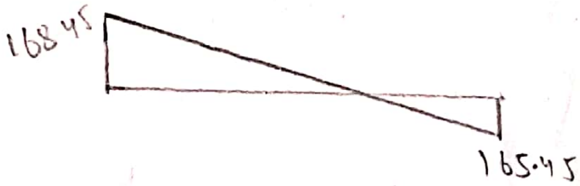


Now moment at change point, find shear point



$$\frac{168.45}{x} = \frac{165.45}{6-x}$$

$$168.45(6-x) = 165.45(x)$$

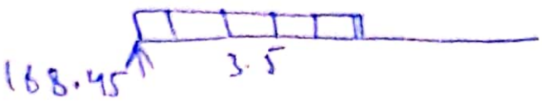
$$1010.7 - 168.45x = 165.45x$$

$$1010.7 = 168.45x + 165.45x$$

$$\frac{1010.7}{333.9} = \frac{333.9x}{333.9}$$

$$\boxed{x = 3.0269}$$

As we know that moment is maximum where shear force is zero.
Take section at 3.0269 from left support and find moment.



$\Sigma M_{3.0269} = 0 \quad +$

$M_{3.0269} - 168.45 \times 3.0269 + 3\overset{1.5134}{\left(\frac{3.0269}{2}\right)} = 0$

$M_{3.0269} - 168.45 \times 3.0269 + 4.502 = 0$

$M_{3.0269} - 509.8813 + 4.5402 = 0$

$M_{3.0269} = 509.8813 - 4.5402$

$\boxed{M_{3.0269} = 505.3411}$

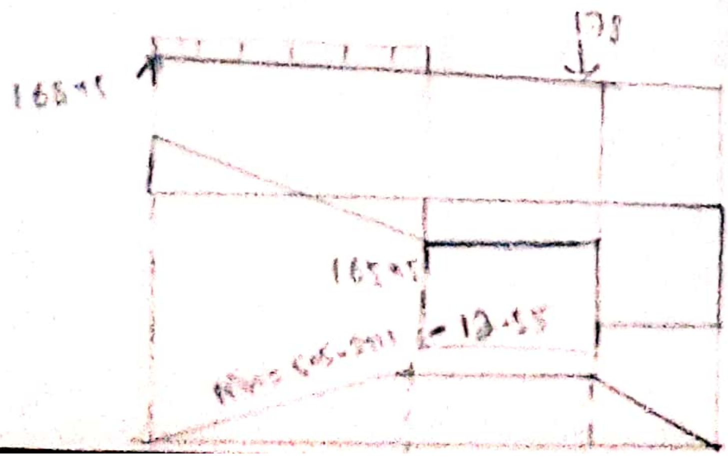
Now:-

$M_{6ft} = 168.45 \times 6 + 0.5 \times 6 \times 3 = 0$

$M_{6ft} = 1010.7 + 9 = 0$

$M_{6ft} = 1010.7 - 9$

$\boxed{M_{6ft} = 1001.7}$



Now,

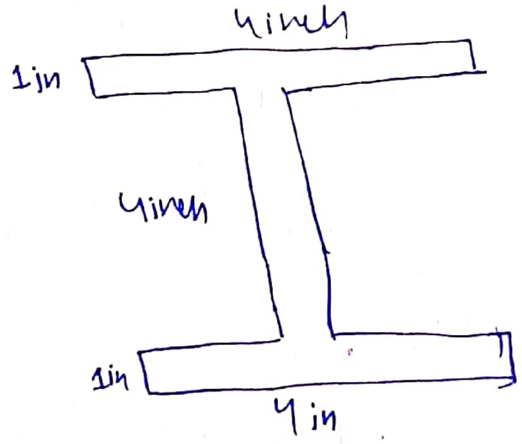
<u>shear stresses:-</u>

As per section the moment shear stresses $\tau = \frac{VQ}{It}$ cross where the moment shear force lies in a point non shear force is 168.45 lb

So,
To find the shear stress we have the following formula.

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

First we find the moment of Inertia



As we know that to find centroid, we have the following formula.

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

$A_1 = 4 \times 1 = 4$

$A_2 = 4 \times 1 = 4$

$A_3 = 4 \times 1 = 4$

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

$\boxed{\bar{y} = 3}$

Now moment of inertia

I_x No $A(m^2)$ $I_n(m)$

1. 0

2. $\frac{4 \times (1)^2}{12} = 0.333$

3. $\frac{4 \times (4)^2}{12} = 5.336$

4. $\frac{4 \times (1)^2}{12} = 0.333$

Now

$d = (\bar{y} - y_1) - (3 - 0.5) = 2.5$

$2d = (\bar{y} - y_2) - (3-3) = 0$

$3d = (3 - 5.5) = 2.5$

(Now Id^2)

1. $4 \times (2.5)^2 = 2.5$

2. $4 \times (0)^2 = 0$

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

so $5.333 + 0 = 5.333$

$0.333 + 25 = 25.333$

Total

$I = I_{x1} + I_{x2} + I_{x3}$

$I = 25.333 + 5.333 + 25.333$

$$\boxed{I = 55.999 \text{ in}''}$$

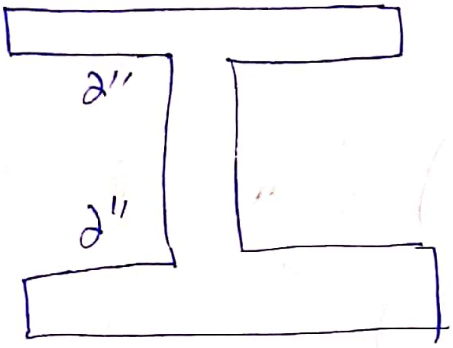
Now shear stresses

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

$$\boxed{V_{maximum} = 168.45}$$

$Q = 7A$

let two value
3 , 7
$y = 7$
7 greater than 3



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

$A = 1 \times 4 = 4$

$Q = 4 \times 2.5 = 10$

so we know that

$$t = \frac{(168.45)(10)}{(55.999)(4)}$$

$$\boxed{t = 1684.5}$$

$$\boxed{t = 7.5202}$$

$$\boxed{t = 1684.5}$$

$$\boxed{t = 7.5202}$$

Now flexer stresses Analysis

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

Where M is Maximum moment

$M = 1.5$

$$\sigma = \frac{1.5\,(2)}{55.996}$$

$$\boxed{\sigma = 0.0535}$$

So shear stress at point C

$$\boxed{t = 7.5202 \text{ psi}}$$

Flexur stress at point "C"

$$\boxed{\sigma = 0.0535 \text{ psi}}$$

Now consider "C" is a planner element 0.0535 is compressive Because point Lie in compression zero of Beam cross Now;

$$\boxed{t = 7.5202 \text{ psi}}$$

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combine stress on 20

$\boxed{7.5202}$ psi

$\boxed{0.0335 \text{ psi}}$

Now we find stress state consider of point "C" at a degree of 20 Clockwise Orientation.

Solve

$\sigma_x = -0.0535$

$\sigma_y = 0$

$\tau_{xy} = 7.5202$

$\sigma_{x'} = ?$

$\sigma_{y} = ?$

$\varepsilon_{x'y'} =$

As we drive the following formula equation for stress transformation,

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

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

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

for $\sigma_{x'}$

for σ_x'

$$\sigma_x' = \frac{-0.0535+0}{2} + \left(-\frac{0.0535}{2} \cdot \cos 2(-20)\right)$$

$$+ (7.5202)\sin 2(-20)$$

$$\sigma_x' = -0.02675 - 0.02049 - 4.824$$

$$\boxed{\sigma_x' = -4.8693 \text{ psi}}$$ compressive

For $\sigma_y' = \frac{0.0535+0}{2} - \frac{0.0535}{2}\cos(2(-20))$ -7.5102 $\sin(2(-20))$

$$\sigma_y' = 0.02675 + 0.02049 - 4.8221$$

$$\boxed{\sigma_y' = -4.8283 \text{ psi}}$$ compressive

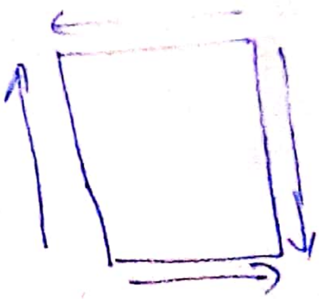
For $\varepsilon_{x'y'}$

$$\varepsilon_{x'y'} = -\left(\frac{-0.0535)-0}{2}\right. \sin 40 + 7.5202\cos(-40)$$

$$\varepsilon_{x'y'} = -0.01719 + 5.7604$$

$$\boxed{\varepsilon_{x'y'} = 5.7432}$$

New stress state after 20° clockwise orientation is shown.



$\sigma_x' = -4.8693$

$\varepsilon_{x'y'} = 5.7432$ psi

Find its principle Stresses:-

We know that principal stress equation is

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

$$\sigma_{1,2} = \frac{-0.0535 + 0}{2} \pm \frac{-0.0535 - 0}{2} \cos(2(-0.44)) + 7.5202 \sin(-40).$$

$$\sigma_{p\,max} = -0.02675 - 0.02675 = -0.0535$$

$$\boxed{\sigma_{p\,max} = -0.0535}$$

These combination show that this given state of stress is itself a principle stress is itself a condition in which the shear stress is approximately equal to zero.

Max in plane shear Stress:-

In this case

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

$$\tan 2\theta_3 = \frac{-0.0535 - 0}{7.5202}/2$$

$\tan 2\theta_3 = \frac{-0.007114}{2}$

$\tan 2\theta_3 = -0.003557$

$2\theta = \tan^{-1}(-0.003557)$

$2\theta = -0.2033$

$\theta = \frac{-0.2037150}{2}$

$\boxed{\theta = -0.1018575}$

To Draw Mohr's circle for the given problem:-

As we know to draw a circle we need the co-ordinate of circle as well as the radius of circle.

we also know that for mohr's circle the coordinate of centre is $\left(\frac{\sigma_x + \sigma_y}{2}, 0\right)$

$(h,k) = \left(\frac{-0.0535+0}{2}, 0\right)$

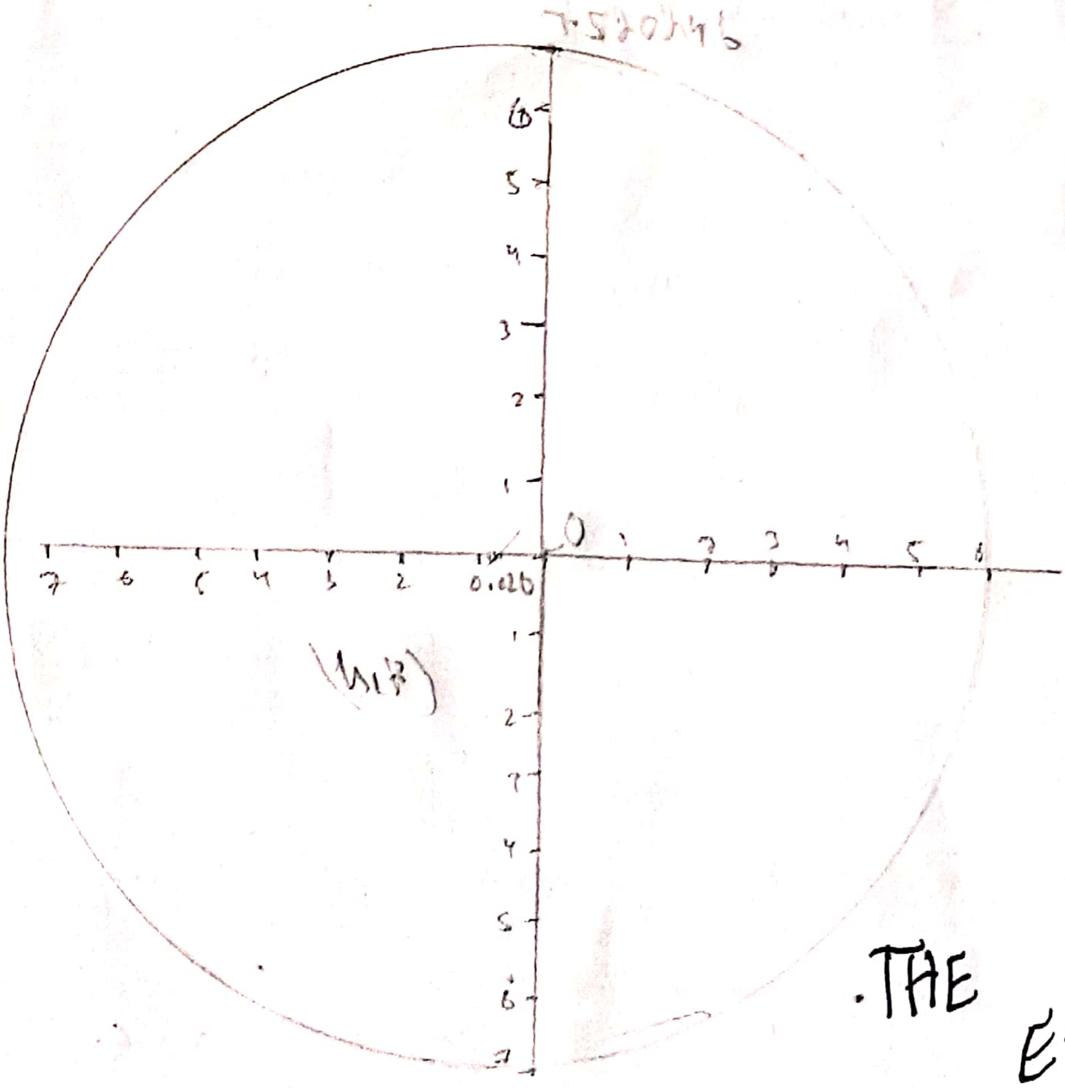
$\boxed{(h,k) = (-0.02675, 0)}$ Co-ordinate

Radius of mohr's circle is

$$r = \sqrt{\frac{\sigma_x - \sigma_y}{2} + \tau_{xy}^2} = \sqrt{\left(\frac{-0.0535 - 0}{2}\right)^2 + (7.5202)^2}$$

$$r = \sqrt{0.00071 + 56.5534} = \sqrt{56.55411}$$

$$\boxed{r = 7.520246}$$



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