ID 7904

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Section:- A

Subject:- MOS II

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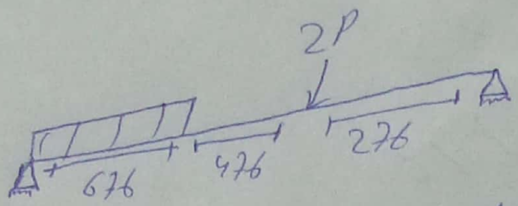
QUESTION :-

Construct the Mohr's circle diagram and the Principle stress and maximum 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 Moh's circle it is necessary 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



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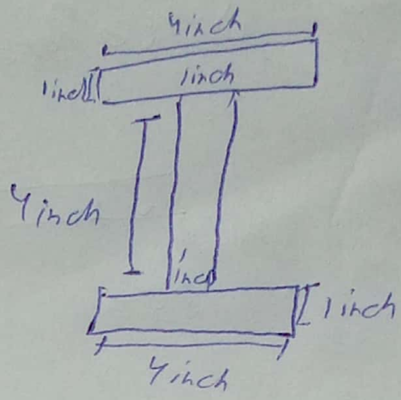
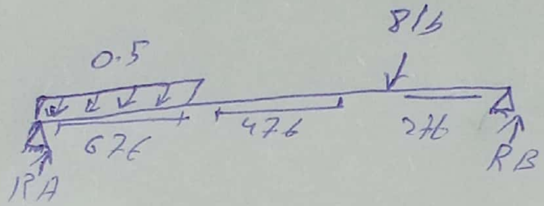
So $2P = 2 \times 04 = 8Lb$





Support Reactions

$$RA + RB = 8.5$$

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

$$RB \times 12 - 8 \times 10 - 3 \times 3$$

$$12RB = 80 + 9$$

$$\frac{\cancel{12} RB}{\cancel{12}} = \frac{89}{12}$$

$$RB = 7.416$$

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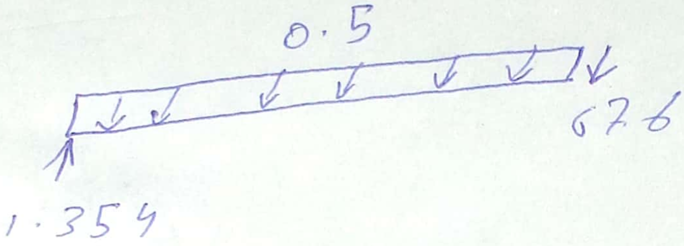
$RA + RB = 8.5$

$RA + 7.416 = 8.5$

$RA = 8.5 - 7.146$

$\boxed{RA = 1.354}$

Now Sheaforce



$\uparrow + \quad \downarrow -$

$\sum F_y = 0$

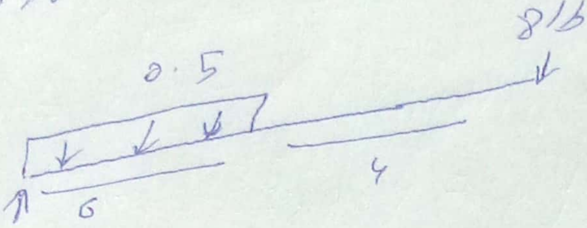
$-V676 + 1.354 - 0.5 \times 6 = 0$

$V676 = 1.354 - 3$

$\boxed{V676 = -1.646}$

shear force at 10 ft

$V_{10ft} = ?$



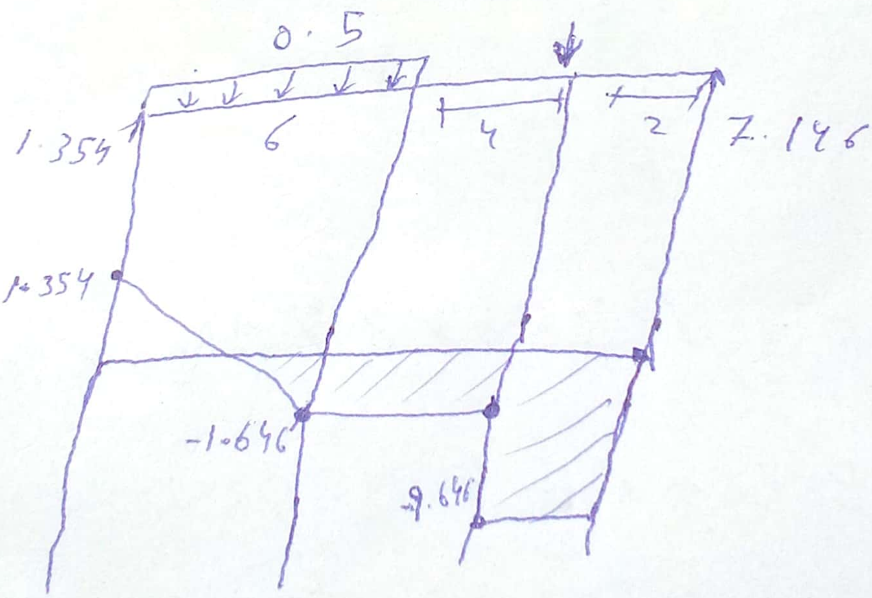
1.354

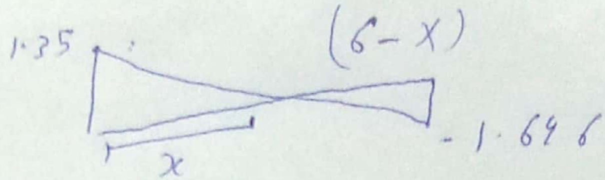
$\sum F_y = 0$ ↑+ ↓−

$\Rightarrow 1.354 - 3 - 8 - V_{10ft} = 0$

$\Rightarrow V_{10ft} = 1.354 - 3 - 8$

$\boxed{V_{10ft} = -9.646}$





$$\frac{1.35}{x} = \frac{1.646}{(6-x)}$$

$$(6-4)\,1.35 = 1.646(x)$$

$$8.1 - 1.35x = 1.646x$$

$$8.1 = 1.646x + 1.35x$$

$$\frac{8.1}{2.996} = \frac{\cancel{2.996}\,x}{\cancel{2.996}}$$

$$\boxed{x = 2.7036}$$

$$\Sigma m = 0 \circlearrowleft^{+}$$

$$M_{2.7036} + 1.354 \times 2.7036 - 3\left(\frac{2.7036}{2}\right) = 0$$

$$M_{2.7036} + 3.6606 - 4.0554 = 0$$

$$M_{2.7036} = 4.0554 - 3.6606$$

$$\boxed{M_{2.7036} = 0.3948}$$

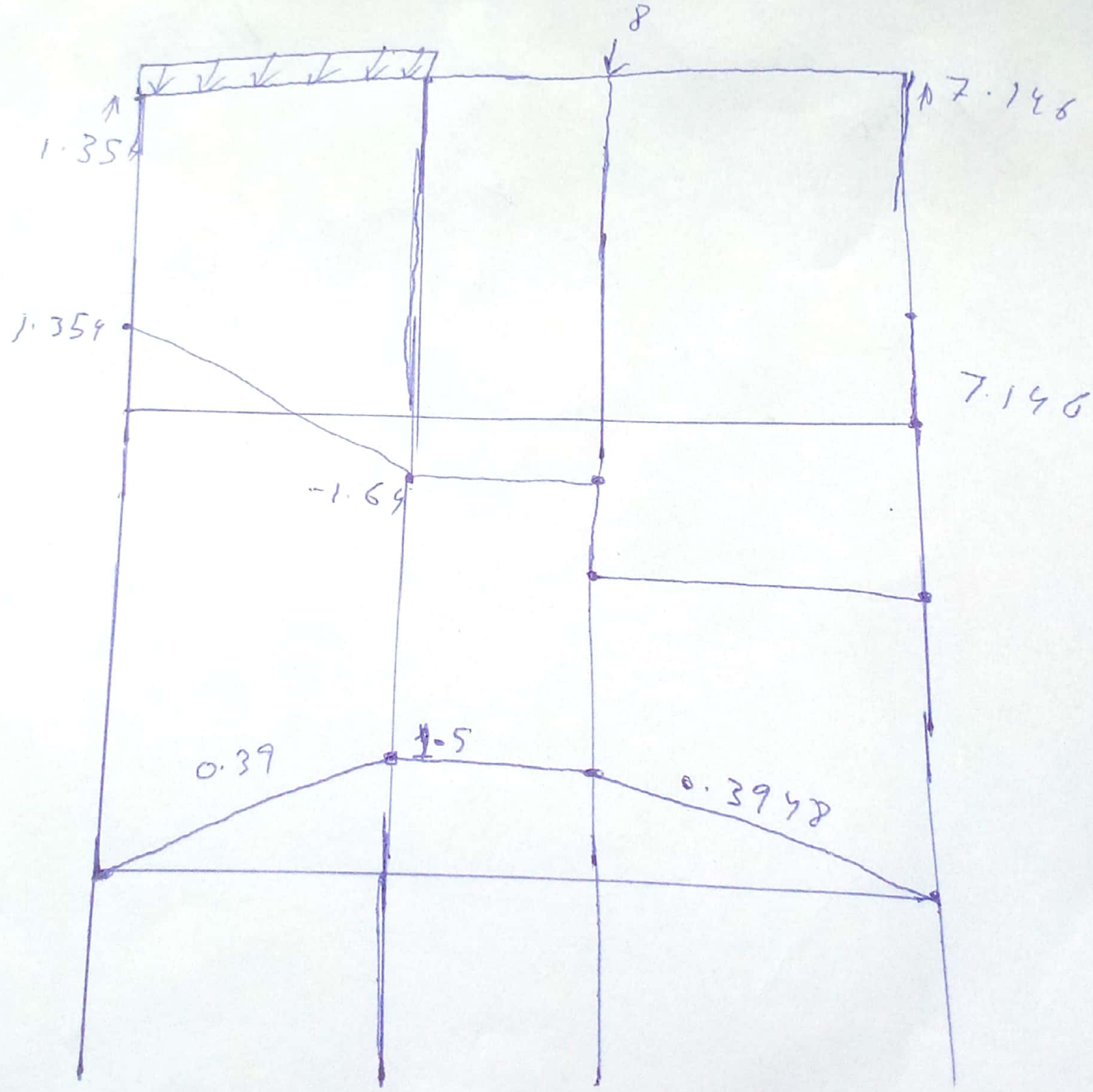
Now

$M_{676} - 1.75 \times 6 + 0.5 \times 6 \times 3 = 0$

$M_{676} - 10.5 + 9 = 0$

$M_{676} + 10.5 - 9$

$\boxed{M_{676} = 1.5}$

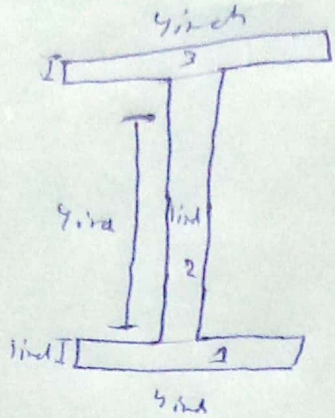


Now
Shear stress

As Question the Maximum shear stress $\tau = \frac{VQ}{It}$ occurs where the maximum shear force lies in above diagram.
So
shear force = 7.146
To find the shear stress we have the following formula

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

we first find the moment of inertia



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

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

$A_1 = 4 \times 1 = 4$
$A_2 = 4 \times 1 = 4$
$A_3 = 4 \times 1 = 4$

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

$$\bar{y} = 3$$

Now moment of inertia

No $A(in^2)$ $I_n(in)$

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

$(\bar{y} - y_1)(\bar{y} - y_2)$

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

2) 4 $\frac{1 \times (4)^3}{12} = 5.333$

3) $\frac{4 \times (1)^3}{12} = 0.333$

(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 d^2)

(1) $4 \times (2.5)^2 = 25$

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

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

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$I_x = \bar{I}_x + Ad^2$

1) $0.333 + 25 = 25.333$

2) $5.333 + 0 = 5.333$

3) $0.333 + 25 = 25.333$

Total

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

$I = 25.333 + 5.333 + 25.333$

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

Now shear stress

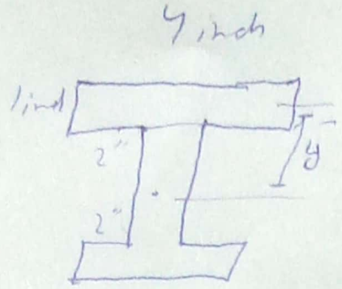
$$\tau = \frac{VQ}{Ib}$$

$V_{max} = 7.146$

$Q = \bar{y}A$

b = breath of that fiber

shear stress at point C located centre of uniformly distributed load and 1inch below the top fiber



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

$A = 1 \times 4 = 4$

$Q = 4 + 2.5 = 10$

As we know that

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

$$t = \frac{(-7.146)(10)}{(55.996)(4)}$$

$$t = 0.3190$$

Now Flexural stress Analysis

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

where M is maximum moment in BMD

$$M = 1.5$$

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

$$\boxed{\sigma = 0.0555}$$

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So, shear stress at point "C" is

$t = 0.475$ Psi

Flexural stress at point "C"

$\sigma = 0.0535$ Psi

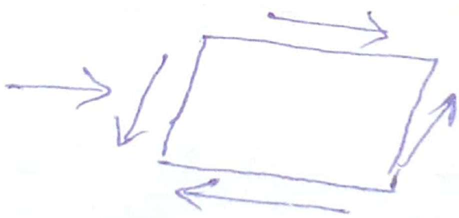
Now consider "C" is a Planes element

$\sigma = 0.0535$ Psi

0.0535 Psi is compressive Because point C lies in compression zone of Beam cross Now

$t = 0.475$ Psi

Combine stress on 2D ele

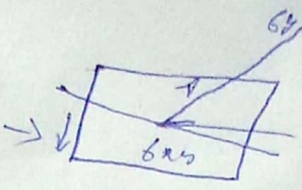


N

Now we can find stress state consid of point 'C' at a degree of 20° clockwise orentation

Solve:

Given stress state



$\sigma_x = -0.0535$

$\sigma_y = 0$

$\tau_{xy} = 0.319$

$\sigma_{x'} = ?$

$\sigma_{y'} = ?$

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

As we Drive the following formula equation for stress transformation

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

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

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

<u>for $\sigma_{x'}$</u>

$$\sigma_{x'} = -\frac{0.0535}{2} + \frac{-0.0535}{2}\cos(2(-20)) + (0.319)\sin 2(-20)$$

$\sigma_{x'} = -0.02675 - 0.0204 - 0.205$

$\boxed{= -0.435 Psi}$ Compressive

For $\sigma_{y'}$

$- \frac{0.0535}{2} - \frac{(-0.0535)}{2} \cos(2(-20))$

$- (0.3190) \sin 2(-20)$

$\sigma_{y'} = -0.02675 - 0.0204 - 0.205$

$\boxed{\sigma_{y'} = -0.435 Psi}$ Compressive

For $\varepsilon_{x'y'}$

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

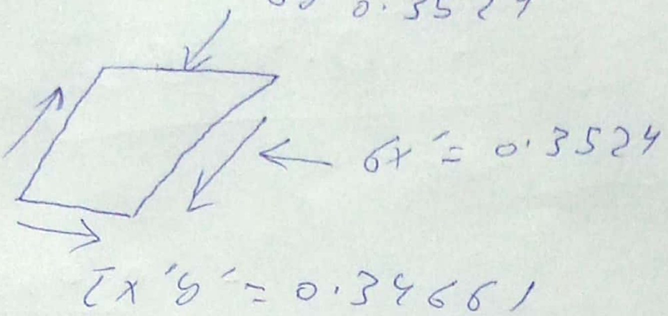
$\varepsilon_{x'y'} = -\frac{(-0.0535) - 0}{2} \sin(2(-20))$

$= + 0.3190 \cos(2(-20))$

$= -0.01719 + 0.3842$

$\boxed{\varepsilon_{x'y'} = 0.3670}$

So, the New stress state after 20° clockwise orientation is shown



Find its Principle stress

$$\sigma_{12} = \frac{\sigma_x + \sigma_y}{2} \pm \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{x'y}^2}$$

$$\sigma_{12} = \frac{-0.0535 + 0}{2} \pm \sqrt{\left(\frac{-0.0535 - 0}{2}\right)^2 + (0.3190)^2}$$

$$\sigma_{12} = -0.0267 \pm \sqrt{7.155 + 0.101761}$$

$$\sigma_{12} = -0.0267 \pm \sqrt{7.2567}$$

$$\sigma_{12} = -0.0267 \pm 2.6938$$

$$\sigma_y = \sigma_1 = -0.0267 + 2.6938 = 2.6677$$

$$\sigma_x = \sigma_2 = -0.0267 - 2.6938 = -2.7205$$

Max in plane shear stress

$$\tau_{xy} = \sqrt{\left(\frac{\sigma x - \sigma y}{2}\right)^2 + \tau_{xy}^2}$$

$$\tau_{xy} = \sqrt{\left(\frac{-0.0535-0}{2}\right)^2 + (0.3190)^2}$$

$$\tau_{xy} = \sqrt{0.00071 + 0.101761}$$

$$\tau_{xy} = \sqrt{0.102471}$$

$$\boxed{\tau_{xy} = 0.3201109 \text{ psi}}$$

To Draw mohr's Circle for the Given Problem

Solve

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

The coordinates of circle can find by this

$$\left(\frac{\sigma x + \sigma y}{2} , 0 \right)$$

Centre coordinates

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

$$= (-0.026, 0)$$

Radius of Moh's circle is

$$r = \sqrt{\left(\frac{\sigma x - \sigma y}{2}\right)^2 + \varepsilon xy^2}$$

$$r = \sqrt{\left(\frac{-0.0535 - 0}{2}\right)^2 + (0.3190)^2}$$

$r = \sqrt{0.000715 + 0.101761}$

$r = \sqrt{0.102476}$

$\boxed{r = 0.3201}$