Mid term Exam

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Sec:- B

Semester:- 4^{th}

Deptt:- BE Civil Engg

Subject:- MOS-II

Submitted to:- Sir Saqib

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Q1.) 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 in figure. However to Construct the Mohr's circle it is necessary to draw the shear Stress and flexural stress variation diagram for Maximum shear force and bending moment respectively.

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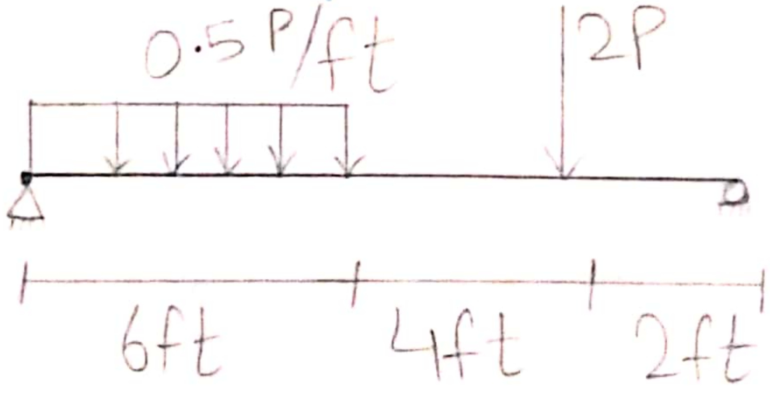
Compare the results obtained from the Mohr's Circle with the stress transformation equations.

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 ID numbers in pounds.



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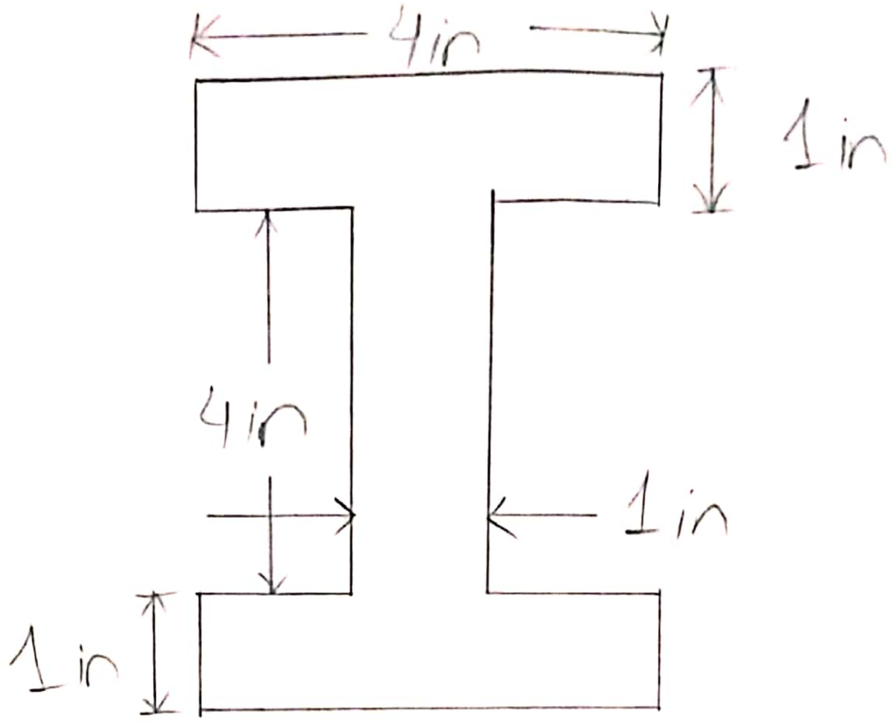


Sol:-

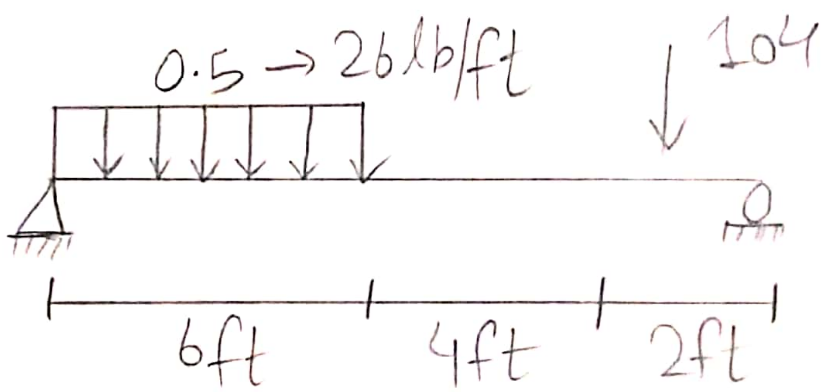
P = 52 pounds

$= 52/2$

$= 26$ lb/ft

$= 52 \times 2$

$= 104$



$\Sigma fy = 0 \uparrow +$

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$$\Rightarrow R_A + R_B - 26 \times 6 - 104 = 0$$

$$\Rightarrow R_A + R_B - 260 = 0$$

$$R_A + R_B = 260 \rightarrow (i)$$

$$\circlearrowleft + \Sigma M_A = 0$$

$$\Rightarrow -(26 \times 6 \times 3) - (104 \times 10) + (R_B \times 12) = 0$$

$$12 R_B = 1508$$

$$R_B = 125.666 \, lb$$

Now, Put in eq (i)

$$R_A + R_B = 260$$

$$R_A + 125.666 = 260$$

$$R_A = 260 - 125.666$$

$$R_A = 134.34 \, lb$$

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Now,

At 6ft:-

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

$$-V_{6ft} + 134.34 - 26 \times 6 = 0$$

$$V_{6ft} = -21.66 \text{ lb}$$

At 10ft:-

$$\Sigma f_y = 0 \uparrow +$$

$$\Rightarrow 134.34 - 26 \times 6 - 104 - V_{10ft} = 0$$

$$V_{10ft} = -125.66 \text{ lb}$$

Now,

Shear force And Bending Moment Diagram:-

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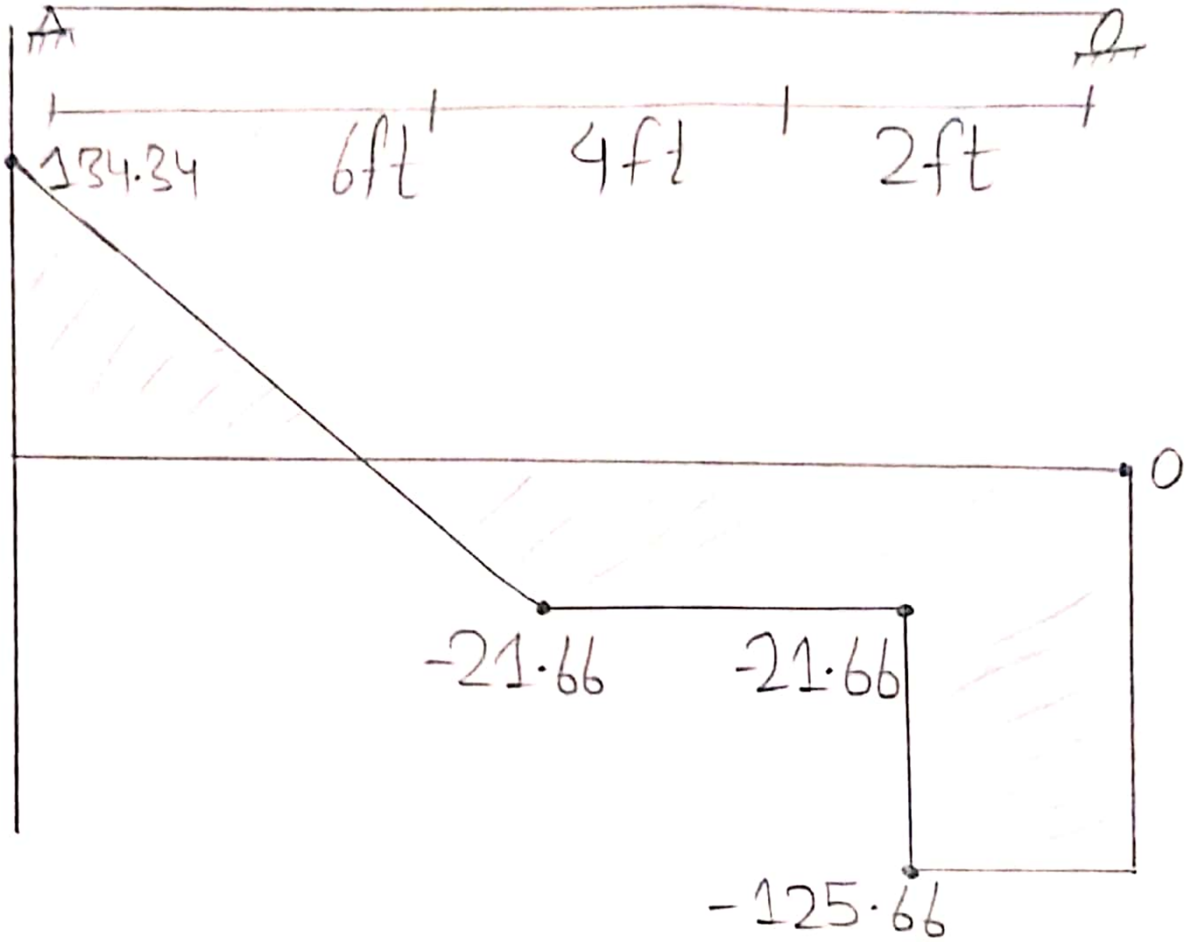
Shear force diagram:-



$$\frac{134.34}{x} = \frac{21.66}{6-x}$$

$$(134.34)(6-x) = 21.66x$$

$$x = 5.16$$

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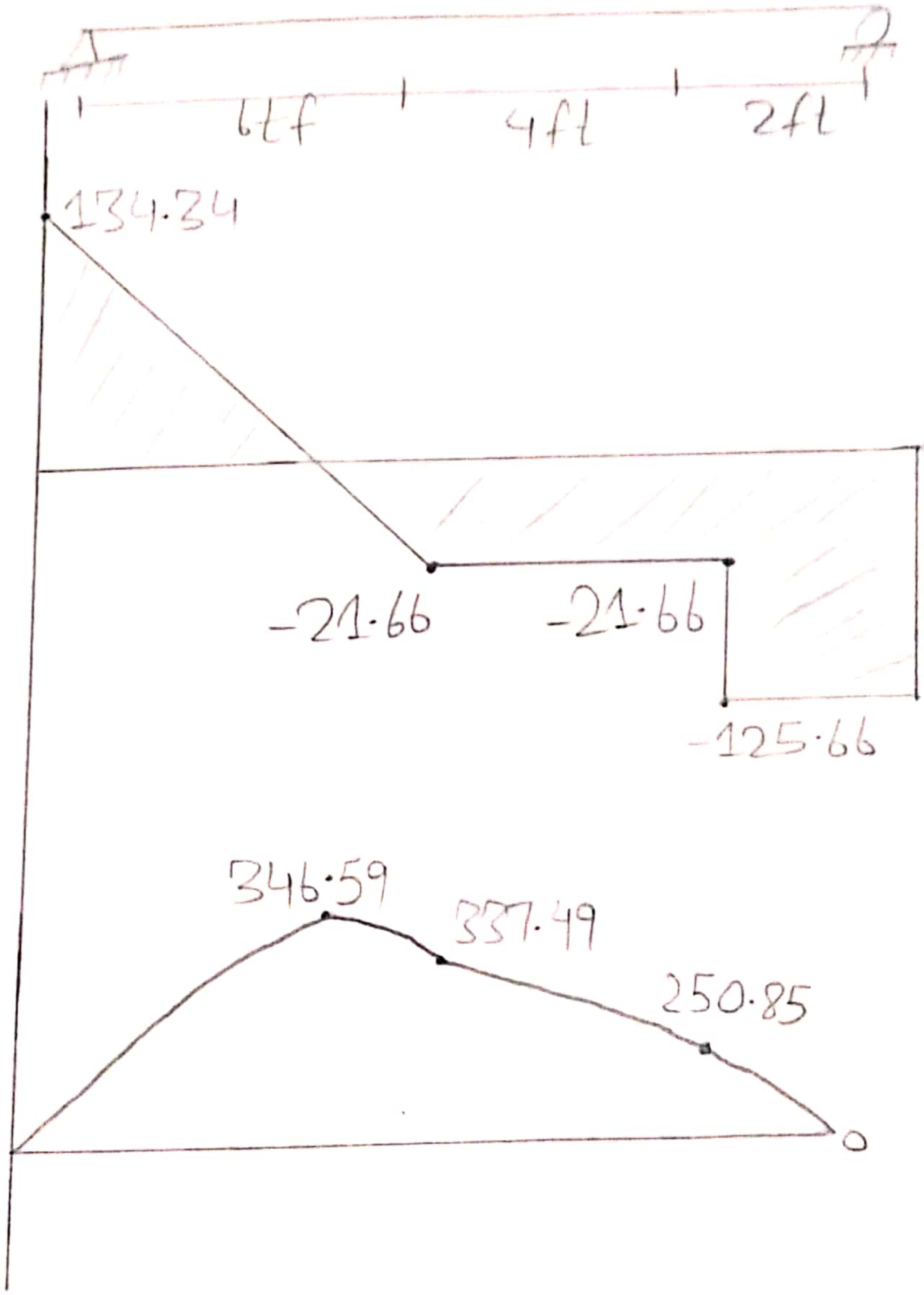
Shear force And Bending Moment Diagrams:-



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Now,

Moment at 3ft which is C point, $\sum M_{3ft} = 0 \circlearrowright +$

$\sum M_{3ft} - (134.34 \times 3) + (26 \times 3 \times 1.5) = 0$

$M_{3ft} = 286.02$ Psi.

$\sum F_y = 0 \uparrow +$

$134.34 - 26 \times 3 - V_{3ft} = 0$

$V_{3ft} = 56.34$ Psi

Shear Stress:-

To find Shear Stress

$\tau = \frac{VQ}{Ib}$ at C point occurs

Wh Dies is 56.34 Psi

Moment of Inertia:-

$$I_{xx} = I_{xx_1} + I_{xx_2} + I_{xx_3}$$

$$I_{xx_1} = \frac{1}{12}(4)(1)^3 + 4(2.5)^2$$

$$I_{xx_1} = 25.33 \text{ in}^2$$

$$I_{xx_2} = \frac{1}{12}(4)^3(1) + 4(0) = 5.33 \text{ in}^2$$

$$I_{xx_3} = \frac{1}{12}(1)^3(4) + 4(2.5)^2$$

$$I_{xx_3} = 25.33 \text{ in}^2$$

$$I_{xx} = I_{xx_1} + I_{xx_2} + I_{xx_3}$$

$$I_{xx} = 25.33 + 5.33 + 25.33$$

For Shear Stress:-

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

$$A = 1 \times 4 = 4 \text{ in}^2$$

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$$Q = 1 \times 4 \times 2.5 = 10 \text{ in}$$

$$\tau = \frac{56.34 \times 10}{56 \times 4}$$

$$\tau = 2.51 \text{ Psi}$$

Flexure Stress:-

The moment at C point is 286.02 Psi,

$$\text{Flexure Stress} = \sigma = \frac{MY}{I}$$

$$\sigma_x = \frac{286.02 \times 12 \times 2}{56}$$

$$\sigma_x = 122.58 \text{ Psi}$$

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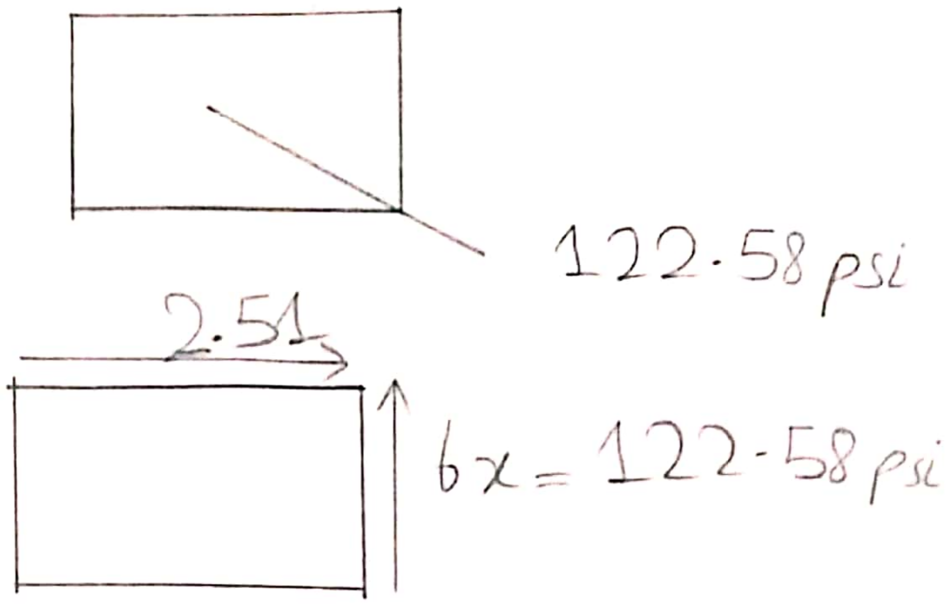

Stress State Condition:-

Assume Angle is 20°
Clockwise orientation

$$\theta = -20°$$

Transformation:-

for σx_1;

$$\sigma x^1 = \frac{\sigma x + \sigma y}{2} + \frac{\sigma x - \sigma y}{2} \times \cos 2\theta$$

$$+ (\overset{\tau xy}{2.51}) \sin 2\theta$$

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$$\sigma x^1 = \frac{-122.58+0}{2} + \frac{-122.58-0}{2} \times \cos 2(-20) + 2.51 \sin 2(-20)$$

$$\sigma x^1 = -110.71$$

for σy^1;

$$\sigma y^1 = \frac{\sigma x + \sigma y}{2} - \frac{\sigma x - \sigma y}{2} \times \cos 2\theta + \cancel{\ } \tau xy \sin 2\theta$$

$$\sigma y^1 = \frac{-122.58+0}{2} - \frac{-122.58-0}{2} \times \cos 2(-20) + 2.51 \sin 2(-20)$$

$$\sigma y^1 = -16.81$$

for $\tau x^1 y^1$;

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$$\tau x^1y^1 = \frac{-6x-6y}{2} \times \sin 2\theta +$$
$$\tau xy \cos 2\theta$$

$$\tau x^1y^1 = \frac{-(-122.58)-0}{2} \times \sin 2(-20)$$
$$+ 2.51 \cos 2(-20)$$

$$\tau x^1y^1 = -37.78.$$

Find its principle Stresses

Principle equation:-

$$6_{1,2} = \frac{6x+6y}{2} \pm \sqrt{\left(\frac{6x-6y}{2}\right)^2 + (\tau xy)^2}$$

$$6_{1,2} = \frac{-122.58+0}{2} \pm \sqrt{\left(\frac{-122.58-0}{2}\right)^2 + (2.51)^2}$$

$$6_{1,2} = -61.29 \pm 61.34$$

$$6_{1,2} = 6x, 6y$$

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$\sigma_y = \sigma_1 = -61.29 + 61.34 = 0.05\ Psi$

$\sigma_x = \sigma_2 = -61.29 - 61.34 = -122.63$

Find $\theta_p = ?$

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

$$\tan 2\theta_p = \frac{2.51}{(-122.58-0)/2}$$

$$\theta_p = -2.82$$

Put in general equation:-

$$\sigma^1_{MAX} = \frac{-122.58+0}{2} + \frac{-122.58-0}{2}$$

$$\cos 2(-2.82) + 2.51$$

$$\sin 2(-2.82)$$

$$\sigma^1_{MAX} = -122.52\ Psi$$

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Max in plane Shear Stress :-

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

$$\tan 2\theta_s = \frac{-(-122.58-0)/2}{2.51}$$

$$\theta_s = 43.82$$

Put in general Solution for $\tau_{x^1y^1}$,

$$\tau_{x^1y^1} = -\left(\frac{\sigma_x - \sigma_y}{2}\right) \sin 2\theta + \tau_{xy} \cos 2\theta$$

$$\tau_{x^1y^1} = -\left(\frac{-122.58-0}{2}\right) \sin 2(43.82) + 2.51 \cos 2(43.82)$$

$$\tau_{x^1y^1} = 61.34 \text{ Psi}$$

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Mohr's Circle;

Centre Coordinates:-

$$(h,k) = \left(\frac{-122.58+0}{2}\right)$$

$$(h,k = (-61.29, 0)$$

Radius of Mohr's Circle,

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

$$r = \sqrt{\left(\frac{-122.58-0}{2}\right)^2 + (2.51)^2}$$

$$r = 61.29 \text{ Psi}$$

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Mohr's Circle Diagram:-