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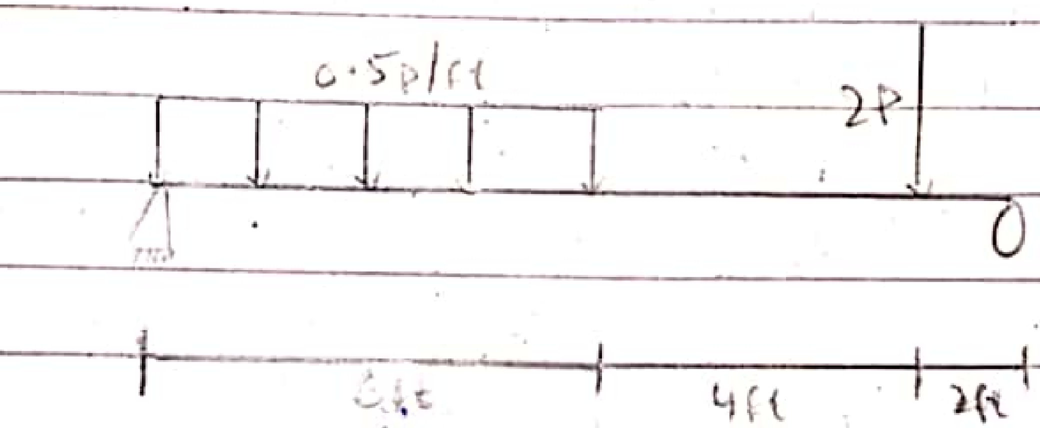
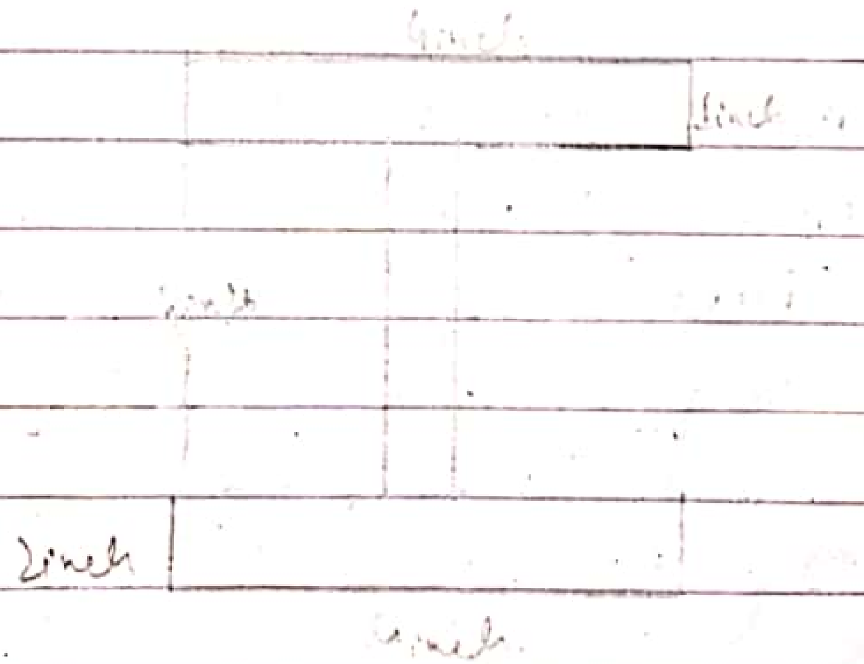
SECTION	"B"
Deptt:	BE Civil

Question : 2.

Construct the Mohr's Circle diagram and --- - - -
- - - - - - - - - - - - -
- - - - - - - - equations?





REACTION:-

$\sum F_y = 0$ ↑+ upward is positive.

$R_A + R_B - 28.5 \times 6 - 114 = 0$

$R_A + R_B = 285 \rightarrow (A)$

$\sum M_A = 0$ ↺+ Anticlockwise is +tive

$R_B(12) - 114(10) - 28.5(6) \times 3 = 0$

$R_B(12) - 1653$

$R_B = \dfrac{1653}{12}$

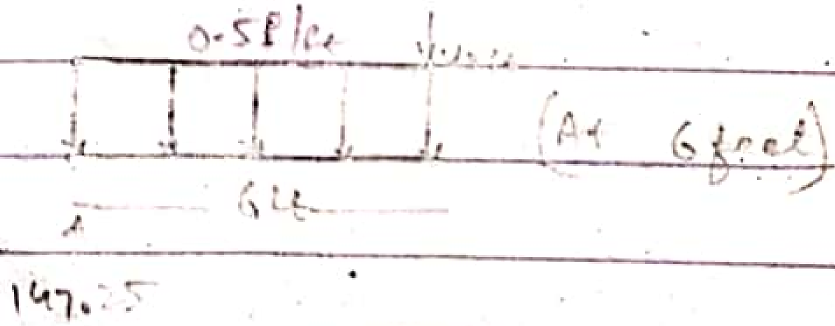
$R_B = 137.75 \text{ lb}$

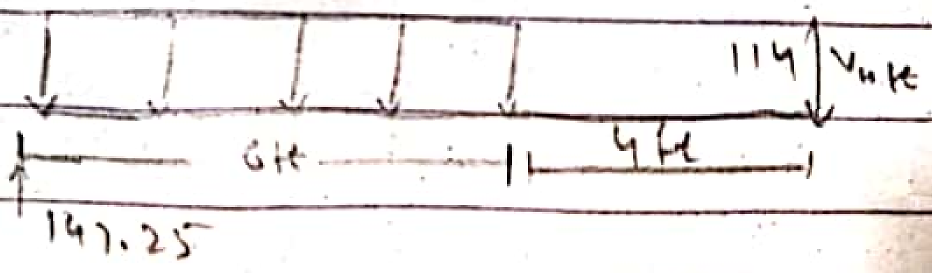
Now

$R_A = 285 - 137.75$

$R_A = 147.25$

SHEAR FORCE:-





$\Sigma F_y = 0 \uparrow +$ (At 6ft from left support)

$-V_{6ft} + 147.25 - 28.5 \times 6 = 0$

$V_{6ft} = -23.75$ lb

$\Sigma F_y = 0$ (At 10ft from left support)

$147.25 - 28.5 \times 6 - 114 - V_{10ft} = 0$

$-137.75 - V_{10ft} = 0$

$= V_{10ft} = \cancel{137}. \; = 137.75$

$V_{10ft} = -137.75$

BENDING MOMENT:-

$\Sigma M_{6ft} = 0$

$\Sigma M_{6ft} = -147.25(6) + 28.5(6)(6/3)$

$\Sigma M_{6ft} = \cancel{-}541.5$

Now we have to find moment at 3ft

$\Sigma M_{3ft} = 0$

$\Sigma M_{3ft} = -147.25(3) + 28.5(6)(3)$

$= 71.25$

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Now we have to find the moment at change point

$$\frac{147.25}{x} = \frac{23.75}{(6-x)}$$

$$147.25(6-x) = 23.75(x)$$

$$853.5 - 147.25x = 23.75x$$

$$853.5 = \cancel{23.75}x + 147.25x$$

$$853.5 = 171x$$

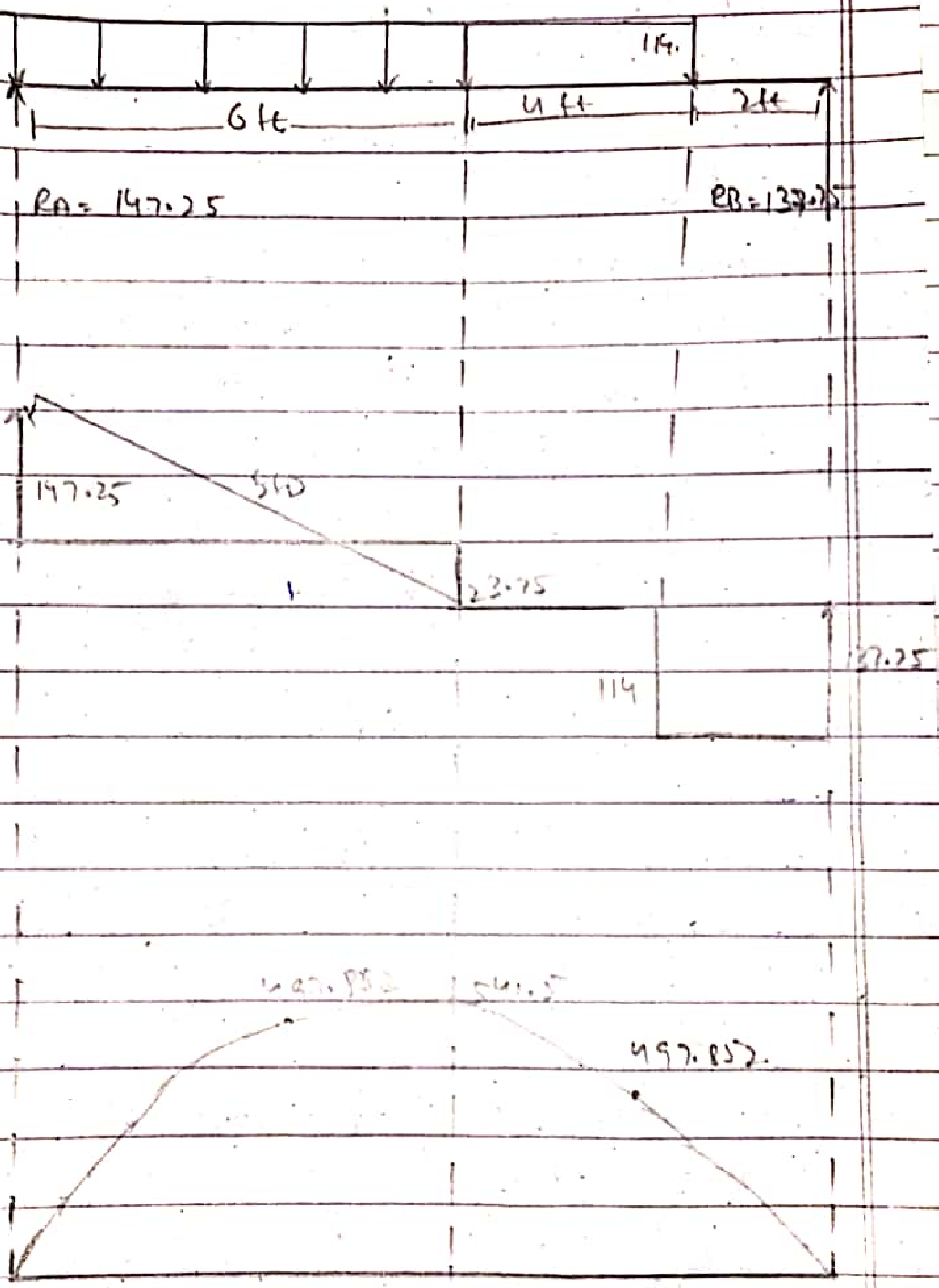
$$x = 4.991\ ft$$

$$\Sigma M_{4.991ft} = 0 +$$

$$\Sigma M_{4.991} = -147.25(4.991) + 23.5(6)(4.991)/3$$

$$\Sigma M_{4.991} = 497.852\ lbft.$$

4(b)



1k.
6 ft
4 ft
2 ft
RA = 147.25
RB = 137.75
147.25
23.75
114
137.75
541.5
497.852.

MOMENT OF INERTIA:-

$y_1 = 5.5$

$y_2 = 3$

$y_3 = 0.5$

$A_1 = 4 inch^2$

$A_2 = 4 inch^2$

$A_3 = 4 inch^2$

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

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

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

$$I_1 = \frac{bh^3}{12} \qquad I_3 = \frac{b \times h^3}{12}$$

$$I_1 = \frac{4 \times 1^3}{12} \qquad I_3 = \frac{4 \times 1^3}{12}$$

$I_1 = 0.33 inch^4$ $\qquad$ $I_3 = 0.33 inch^4$

$$I_2 = \frac{b^3 \times h}{12}$$

$$I_2 = \frac{4^3 \times 1}{12}$$

$I_2 = 5.33 \text{ inch}^4$

$\boxed{d}$	$\boxed{Ad^2}$
$d_1 = \bar{y}' - y_1$	① $A_1 d_1^2$
	$= 4 \times (-2.5)^2$
$d_1 = 3 - 5.5$	$= 25 \text{ inch}^4$
$d_1 = -2.5$	
$d_2 = \bar{y}' - y_2$	② $A_2 d_2^2$
$d_2 = 3 - 3$	$= 4 \times 0$
$d_2 = 0$	$= 0$
$d_3 = \bar{y}' - y_3$	③ $A_3 d_3^2$
$d_3 = 3 - 0.5$	$= 4 \times (2.5)^2$
$d_3 = 2.5$	$= 25 \text{ inch}^4$

$I_{1x} = I_1 + A_1 d_1^2$

$I_{1x} = 0.33 + 25$

$I_{1x} = 25.33 \text{ inch}^4$

$I_{3x} = I_3 + A_3 d_3^2$

$I_{3x} = 0.33 + 25$

$I_{3x} = 25.33 \text{ inch}^4$

Now

$I_{xx} = I_{1x} + I_{2x} + I_{3x}$

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

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

SHEAR STRESS:-

$\boxed{\text{For } V = 137.75}$

Case No 1:-

$$\tau_{\text{Top fiber}} = \frac{VQ}{Ib}$$

$$= \frac{137.75 \times 0}{56}$$

$$= 0 \text{ psi}$$

Case No 2:- (for 1 inch below top fiber)

$$\tau_{2A} = \frac{137.75 \times 10}{56(4)} \quad (\because b = 4)$$

$$= 6.149 \text{ psi}$$

Case No 3:-

$$\tau_{2B} = \frac{137.75 \times (10)}{56(1)}$$

$$= 24.59 \text{ psi}$$

$\because Q = \bar{y} \times A$

$\bar{y} = \cancel{2A}/2$

$\bar{y} = 2.5$

$A = 1 \times 4 \times 4$

$Q = 4 \times 2.5$

$Q = 10$

Case No3: (Stress At. Centroidal Axis)

$$\tau_{max} = \frac{VQ}{Ib}$$

$$Q = Q_1 + Q_2$$

$$Q = 10 + 1(2)$$

$$= 12$$

Sol:-

$$\tau_{max} = \frac{137.75 \times 12}{56}$$

$$= 29.517\ psi$$

Case No 4A:- (1 inch above bottom)

$$\tau_{2A} = \frac{VQ}{It} \quad \because b = 4$$

$$= \frac{137.75 \times 10}{56 \times 4}$$

$$= 6.149\ psi$$

Case No. 4B:-

$$\tau_{2B} = \frac{VQ}{It}$$

$$= \frac{137.75 \times 10}{56 \times 1} \quad \because b = 1$$

$$= 24.598\ psi$$

Case No:5 (At Bottom fiber)

$$\tau_{Bottom} = \frac{VQ}{It}$$

$$\therefore \tau_{Bottom} = \frac{137.75 \times 0}{56(4)}$$

$$= 0 psi$$

Case 6:-

shear force at a distance of 3ft from left support of beam a long its length.

$V_{3ft} = -23.75$

$Q = 12$

$$\tau_{max} = \frac{23.75 \times 12}{56(1)}$$

$$= 5.089 psi$$

Case 7:- (At a distance 6 inch below)

For $b = 4$ $\tau_A = \frac{23.75 \times 10}{56(4)} = \boxed{1.058 psi}$

For $b = 1$

$$\tau_B = \frac{23.75 \times 10}{56(1)} = 4.241 psi$$

FLEXURAL STRESS:.

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

Moment = 541.5

Moment of Inertia, I = 56

Case No 1:- (Stress at top fiber)

$$\sigma_{Top} = \frac{My}{I}$$

$$= \frac{541.5 \times 3}{56}$$

$$= 29.008 \text{ psi}$$

Case No: 2 (1 inch below top fiber)

$$\sigma_1 = \frac{My}{I}$$

$$= \frac{541.5 \times 2}{56}$$

$$= \boxed{19.339} \text{ psi}$$

Case No : 3 :- (At Geometrical Centroid)

$$\sigma_{center} = \frac{My}{I} \quad \because y(0)$$

$$= 0 \, psi$$

Case No : 4 :- (1 inch above the bottom)

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

$$= \frac{541.5 \times 2}{56}$$

$$= 19.339 \, psi$$

Case No : 5 :- (At bottom Fiber)

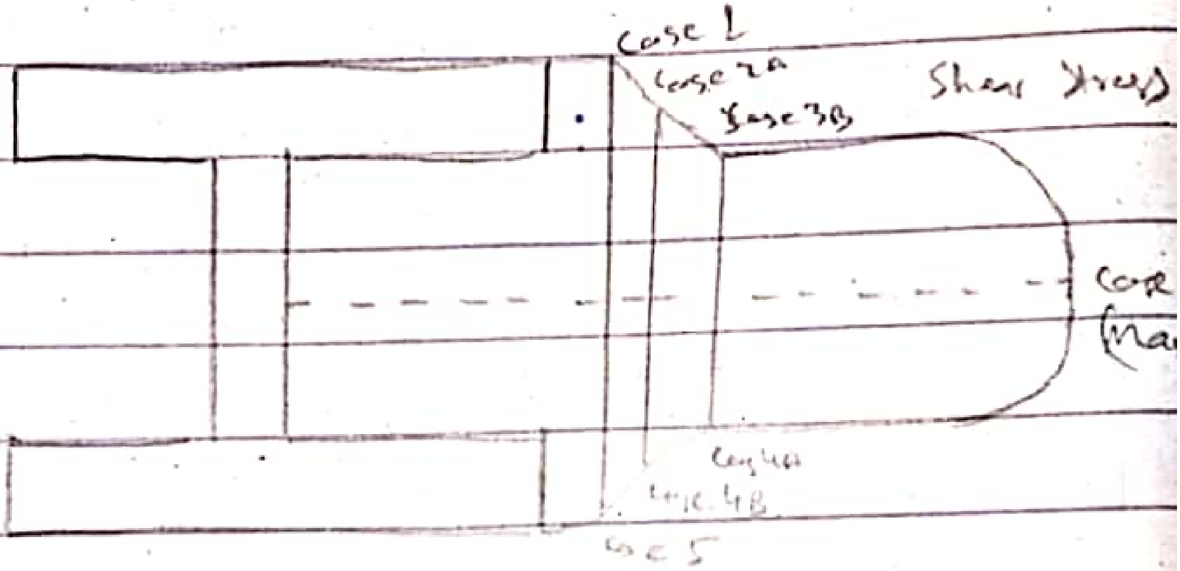
$$\sigma_{Bottom} = \frac{My}{I}$$

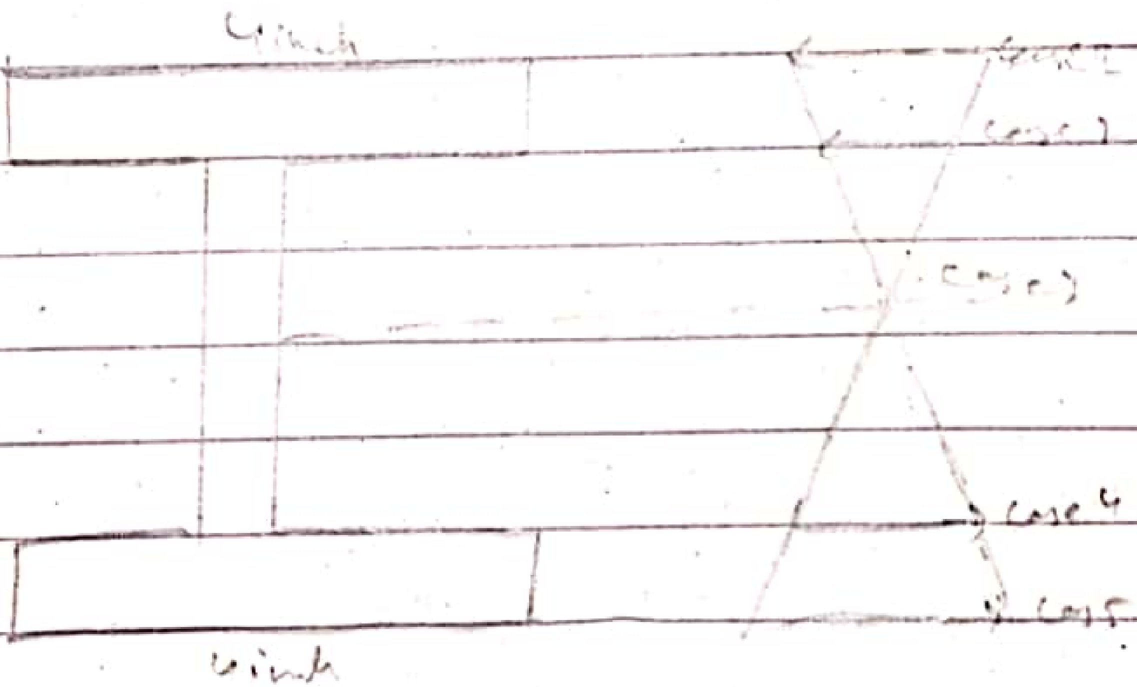
$$\sigma_{Bottom} = \frac{541.5 \times 3}{56}$$

$$= 29.008 \, psi$$

SHEAR FORCE AND BENDING STRESS Diagram

VARIATION:-





* Stress State of a Point Element:

We find all stresses, which is acting on the I section Beam. Given stress state condition is at point c which is the center of Udl at 3ft

Thus Flexural stress at point "c"

$\sigma_x = 19.339$ psi ∴ from case 2, point c lies in this case At 1 inch below top fiber.

Now shear stress at point "c"

$\tau_{xy} = 1.2090$ psi = ∴ from case No 7.

consider this point "c" is a planar element.

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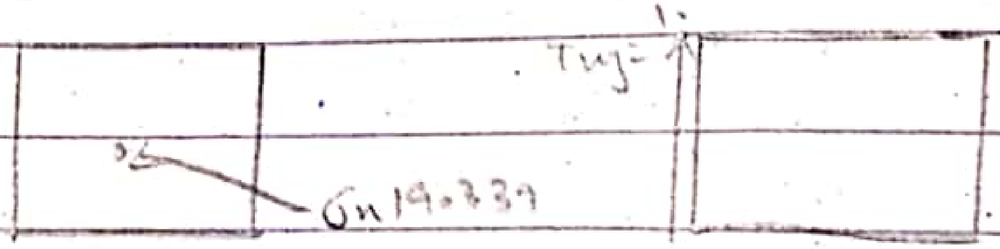
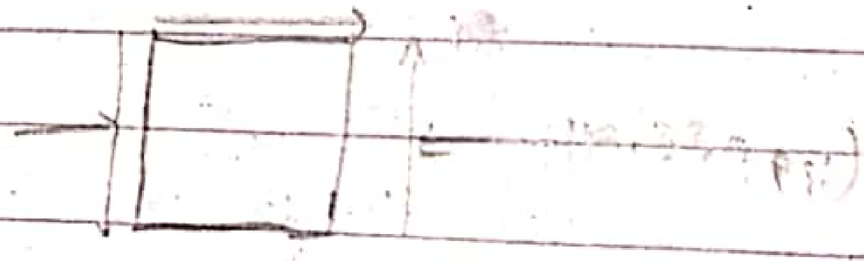
$\sigma_x = -19.339$. Compressive

-19.339 is compressive Because it point lies in the center and in the compression zone of beam cross section.

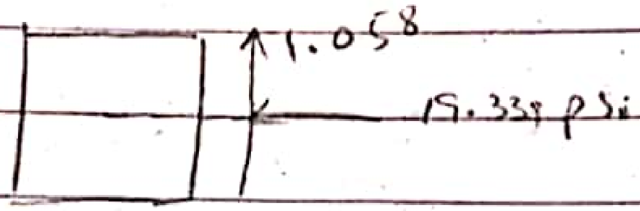
- If point C lies below the centroid then stress would be tensile.



Combine Stress in 2D element.



Stress Transformation.



let assume teta (θ) = -15°

For new orientation.

$\theta = -15$

(clockwise)

Now

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

$$\sigma_{x'} = \frac{-19.339 + 0}{2} + \frac{-19.399 - 0}{2} \cos 2(-15)$$

$$+ 1.058 \{\sin 2(-15)\}$$

$$= -9.699 + -9.699(0.866) + 1.058(-0.5)$$

$$= -18.614 \text{ psi}$$

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

$$\sigma_{y'} = \left(\frac{-19.399+0}{2}\right) - \left(\frac{-19.399-0}{2}\right)\cos 2(-15)$$

$$- 1.058 \{\sin 2(-15)\}$$

$$= -9.699 + 9.699(0.866) \overset{-1.085}{\cancel{-1.058}}(-0.5)$$

$$= -0.753 \text{ psi}$$

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

$$= -\left(\frac{19.399-0}{2}\right)\sin 2(-15) + 1.058\{\cos 2(-15)\}$$

$$= +9.699(-0.5) + 1.058\{0.866\}$$

$$\tau_{x'y'} = \cancel{-5.950 \text{ psi}} \; -4.147 \text{ psi}$$

PRINCIPLE STRESS:-

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

$\sigma_x = -19.399$, $\sigma_y = 0$, $\tau_{xy} = 1.058$

$$\tan 2\theta_p = \frac{1.058}{(19.399-0)/2}$$

$$= \frac{1.058}{-9.699}$$

$$= -0.109$$

$$\tan \theta_p = \frac{-0.109}{2}$$

$$= -0.05$$

$$\theta_p = \tan^{-1}(0.05)$$

$$\theta_p = -2.86^\circ$$

Now

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

$$\sigma_x' = \left(\frac{19.399+0}{2}\right) + \left(\frac{-19.399-0}{2}\right)\cos 2(-2.86)$$

$$+ 1.058\{\sin 2(-2.86)\}$$

$= -9.699 - 9.689(0.99) + 1.058(-0.09)$

$= -19.366 \; psi$

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

$$= \left(\frac{-19.399 + 0}{2}\right) - \left(\frac{-19.399 - 0}{2}\right) \cos 2(-2.88) - (1.058)\{\sin 2(-2.86)$$

$= -9.699 + 9.699(0.99) - 1.058(-0.09)$

$= -0.001 \; psi$

SHEAR STRESS:-

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

$$\tan 2\theta_s = -\left(\frac{(-19.399-0)/2}{\tau_{xy}}\right)$$

$$= \frac{-(-19.399-0)/2)}{1.058}$$

$$\tan 2\theta_s = \frac{9.699}{1.058} \quad \frac{18.335}{2}$$

$$\tan \theta_s = 9.167$$

$$\theta_s = \tan^{-1}(9.167)$$

$$= 74.6°$$

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

$$\tau_{x'y'} = -\left(\frac{-19.399-0}{2}\right) \sin 2(74.6°) + 1.058 \{\cos 2(74.6°)$$

$$= 9.699(0.419) + 1.058(-0.907)$$

$\tau_{x'y'} = 3.09$ psi

MOHR'S CIRCLE:-

Mohr's Circle. Center Cordinates.

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

$$= \left[\frac{-19.399 + 0}{2}, 0 \right]$$

$$= \left[-9.699, 0 \right]$$

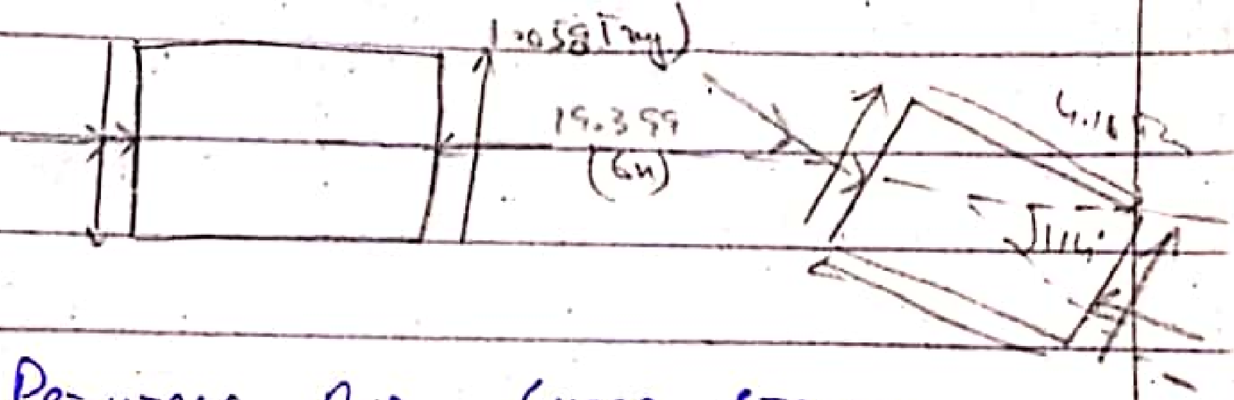
$$\text{Radius}, r = \sqrt{\left(\frac{-19.399 - 0}{2} \right)^2 + (1.058)^2}$$

$$= \sqrt{(-9.699)^2 + (1.058)^2}$$

Radius = 8.699 psi

Result Comprasion:-

$\theta = 0°$ $\theta = 15°$ (clockwise)



PRINCIPLE AND SHEAR STRESS:-

$\theta = 1°$ (Anticlockwise) $\theta = 44.68°$