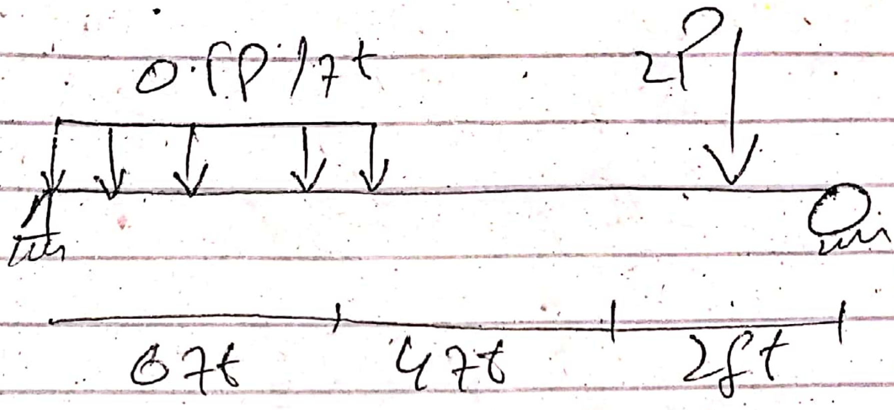
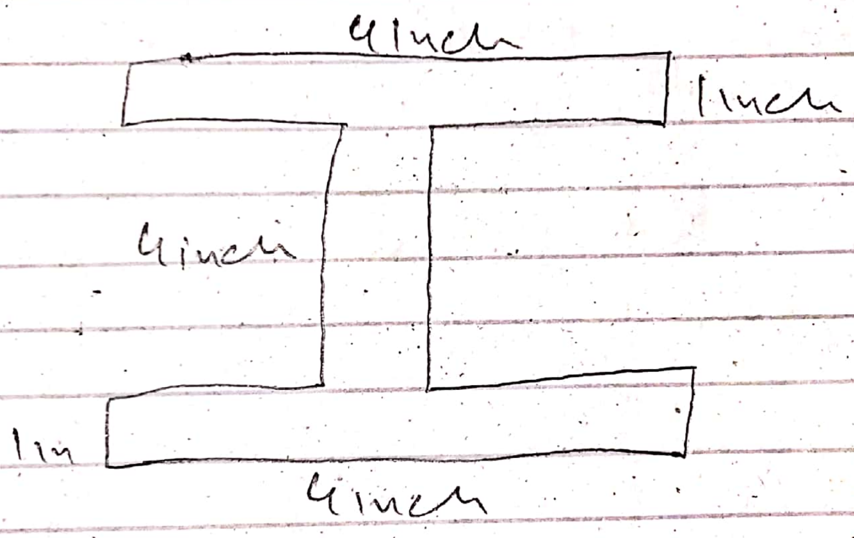
(1)

# MOS II

(8)




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

$R_A + R_B - 32 \times 6 - 128 = 320$

$\Sigma M_A = 0$ $128(10) - 32(6) \times 3 = 0$

$R_B 12 = 1876$

$R_B = \frac{1876}{12}$

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(2)

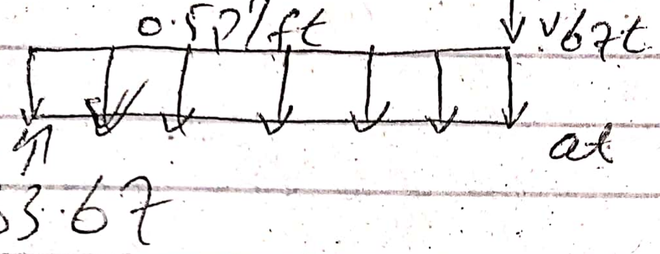
$R_B = 156.33$ lb

Now

$$R_A = 320 - 156.33$$

$$R_A = 163.67$$

## Shear force




at 6 feet

$\Sigma F_y = 0$ at 6ft from left support

$$-V_{6ft} + 163.67 - 32 \times 6$$

$$V_{6ft} = -28.33$$

$\Sigma F_y = 0$ at 10ft from left support

$163.67 - 32\times6 - 128 - V_{10ft} = 0$

$-156.33 - V_{10ft} = 0$

$-V_{10ft} = 156.33$

$V_{10ft} = -156.33$

Bending Moment

$\Sigma M_{6ft} = 0$

$\Sigma M_{6ft} = -163.67(6) + 32(6)(6/3)$

$\Sigma M_{6ft} = 598.02$

at 3ft

$\Sigma M_{3ft} = 0$

$\Sigma M_{3ft} = \cancel{16} + 163.67(3) + 32(6)(3)$

$= 84.88\ \text{lbft}$

Now we find moment at change point

$$\frac{163.67}{x} = \frac{28.33}{(6-x)}$$

$$163.67(6-x) = 28.33(x)$$

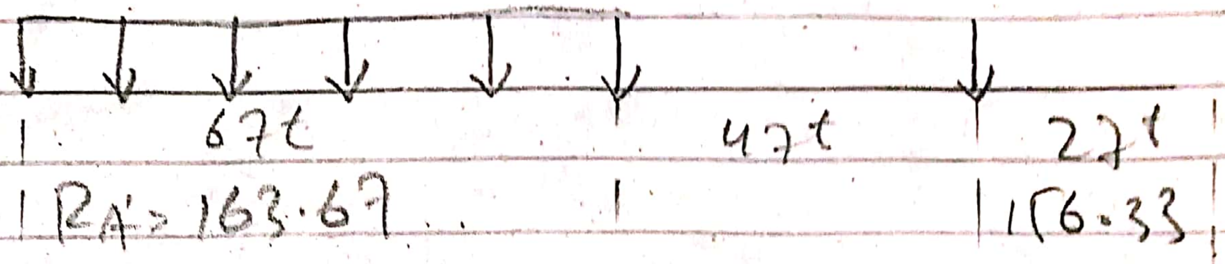
$$x = 5.11 \text{ ft}$$

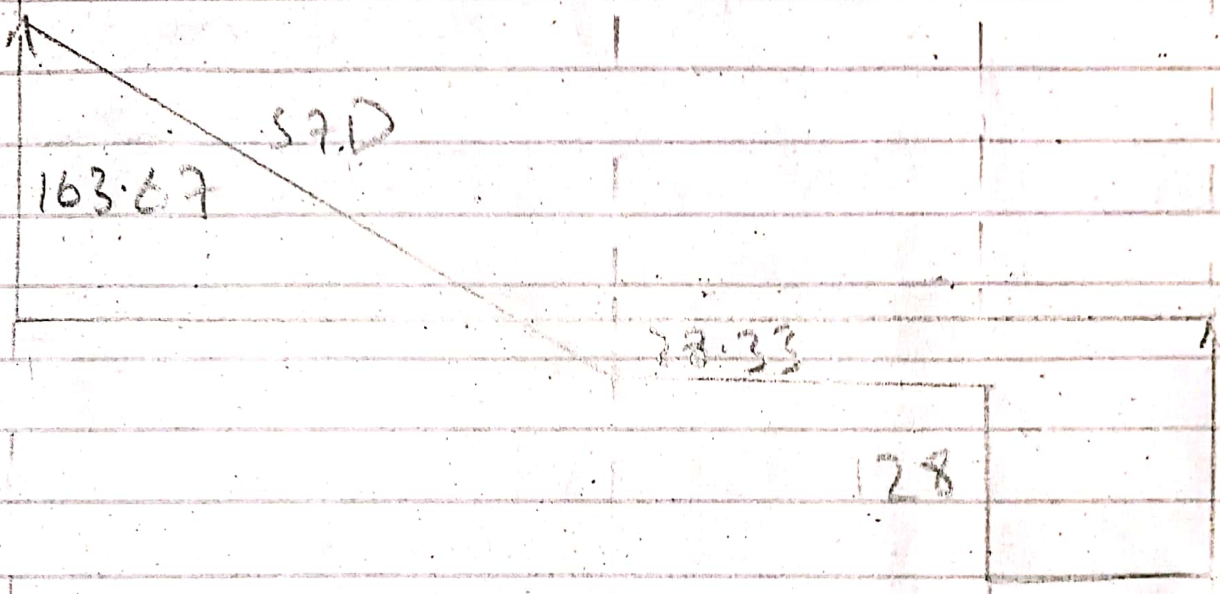
$$\Sigma M_{5.11} = 0 \; + \!\!\!\circlearrowleft$$

$$\Sigma M_{5.11} = -163.87(5.11) + 32(6)\left(\frac{5.11}{3}\right)$$

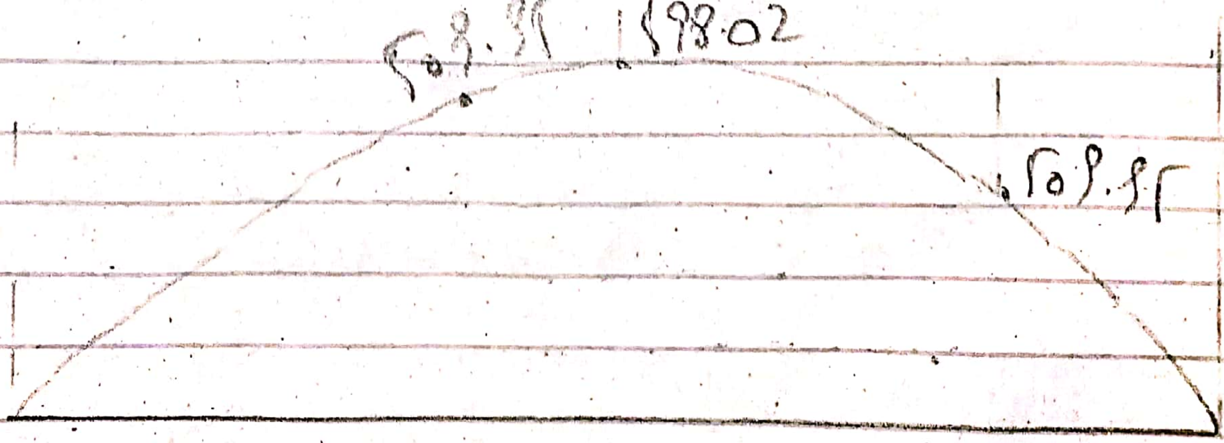
$$\Sigma M_{5.11} = 508.85$$

# Shear Force Bending Moment diagram




BMD



Moment of Inertia

$y_1 = 5.5,\ y_2 = 3,\ y_3 = 0.5$

$A_1 = 4\ inch^2,\ A_2 = 4\ inch^2$
$A_3 = 4\ inch^2$

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

$y = 3''$

$I_1 = \frac{bh^3}{12}$

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

$I_1 = 0.33\ inch^4$

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

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

$I_3 = 0.33\ inch^4$

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

$I_2 = 5.33\ inch^4$

$\boxed{d}$

$d_1 = \bar{y} - y_1$
$d_1 = 3 - 5.5$
$d_1 = -2.5$

$d_2 = \bar{y} - y_2$
$= 3 - 3$
$d_2 = 0$

$d_3 = \bar{y} - y_3$
$= 3 - 0.5$
$d_3 = 2.5$

$\boxed{Ad^2}$

① $A_1 d_1^2$
$= 4 \times (-2.5)^2$
$= 25 \text{ inch}^4$

② $A_2 d_2^2$
$= 4 \times 0$
$= 0$

③ $A_3 d_3^2$
$= 4 \times (2.5)^2$
$= 25 \text{ inch}^4$

$I_{1x} = \bar{I}_1 + A_1 d_1^2$
$= 0.33 + 25$
$= 25.33 \text{ inch}^4$

$I_{x_2} = \bar{I}_2 + A_2 d_2^2$
$= 5.33 \text{ inch}^4$

$I_{x_3} = \bar{I}_3 + A_3 d_2^2$
$= 25.33 \text{ inch}^4$

$I_{xx\cancel{x}} = I_{x_1} + I_{x_2} + I_{x_3}$

$= 25.33 + 5.33 + 25.33$

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

# Shear Stress

For V = 156.33

Case 1:-

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

$$= \frac{156.33 \times 0}{56}$$

$$= 0 \text{ psi}$$

Case 2A:-

For 2 inch below

$$\tau_{1A} = \frac{156.33 \times 10}{56(4)}$$

$$= 6.97 \text{ psi}$$

Case 2B:-

$$\tau_{1B} = \frac{156.33 \times 10}{56}$$

$$\tau_{1B} = 27.91 \text{ psi}$$

Case 3 :- Stress at centroidal Axis

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

$$Q = Q_1 + Q_2$$

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

$$Q = 12$$

$$\tau_{max} = \frac{156.33 \times 12}{56}$$

$$\tau_{max} = 3348 \text{ psi}$$

Case 4A :- 2 inch Above bottom

$$\tau_{2A} = \frac{VQ}{Ib}$$

$$= \frac{156.33 \times 10}{56 \times 4}$$

$$= 6.97 \text{ psi}$$

Case 4B =

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

$$= \frac{156.33 \times 10}{56} = 27.91 \text{ psi}$$

Case 5 :- At bottom fiber

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

$$= \frac{156.33 \times 0}{56}$$

$$= 0 \text{ psi}$$

Case 6 :-

$V_{677} = -28.33$
$Q = 12$

$$\tau_{max} = \frac{28.33 \times 12}{56(1)}$$

$$= 6.07 \text{ psi}$$

Case 7 :- at 1 inch below

$$\tau_A = \frac{28.33 \times 10}{56(4)} \quad ; \quad b = 4$$

$$= 1.26 \text{ psi}$$

$$\tau_B = \frac{28.33 \times 10}{56} \quad ; \quad b = 1$$

$$= 5.05 \text{ psi}$$

Flexural Stress:-

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

Moment = 598.02

$I = 56$

Case 1 :- at top of fiber

$$6_{Top} = \frac{My}{I}$$

$$= \frac{598.02 \times 3}{56}$$

$$= 32.03 \text{ psi}$$

Case 2 :- 1 mm below top

$$6_1 = \frac{My}{I}$$

$$= \frac{598.02 \times 2}{56}$$

$$= 21.35 \text{ psi}$$

Case 3:- at Geometrical centroid

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

$$= 0 \text{ psi}$$

Case 4 :- (2 mm above)

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

$$= \frac{588.02 \times 2}{56}$$

$$= 21.35 \text{ psi}$$

Case 5:- at bottom

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

$$= \frac{588.02 \times 3}{56}$$

$$= 32.03 \text{ psi}$$

# Shear Force & Bending Stress Diagram:

★ Stress State of a Point Element:-

Flexual stress at point 'E'

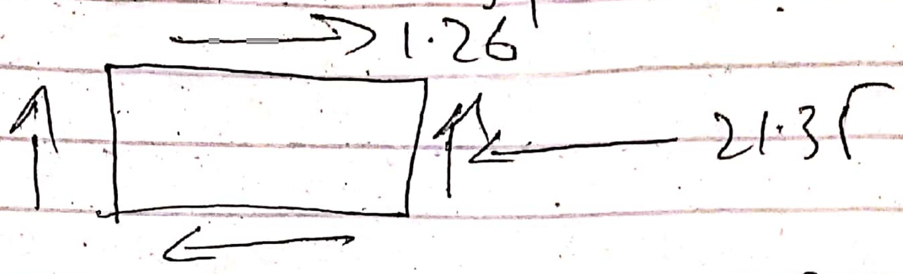
$\sigma_x = 21.35$ psi from Case 2
1 inch below
Top fiber

Now shear stress at point C

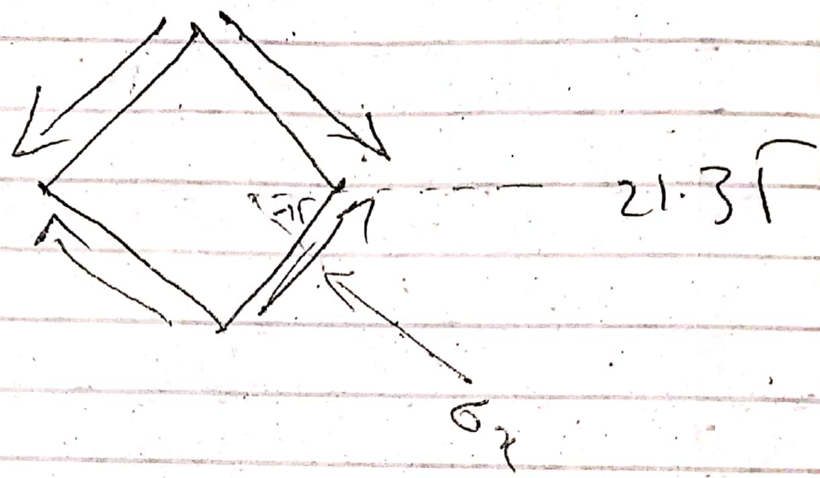
$\tau_{xy} = 1.26$ psi from
Case 7

$\sigma_x = -21.35$ (Compressive)

# Stress Transformation




Let assume $\theta = -15^\circ$




Now

$$\sigma_x = \frac{\sigma_x+\sigma_y}{2} + \frac{\sigma_x-\sigma_y}{2}\cos 2\theta$$

$$+ \tau_{xy} \sin 2\theta$$

$$\sigma_x = \frac{-21.35+0}{2} + \frac{(-21.35-0)}{2}\cos 2(15)$$

$$+ 1.26\{\sin 2(-15)\}$$

$$= -10.67 - 10.67(0.866) + 1.26(-0.5)$$

$$\sigma_x' = -20.54 \text{ psi}$$

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(15)

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

$= -10.67 + 10.67(0.866) - 1.26(-0.5)$

$= -0.7$ psi

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

$= -\left(\frac{-21.35-0}{2}\right)\sin 2(-15) + 1.26\{\cos 2(-15)\}$

$= 10.67(-0.5) + 1.26(0.866)$

$\tau_{x'y'} = -4.24$ psi

Principle stress:

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

$\sigma_x = -21.35 \quad \sigma_y = 0$

$\tau_{xy} = 1.26$

$$\tan 2\theta p = \frac{1.26}{(-21.35)/2}$$

$$= \frac{1.26}{-10.67}$$

$$= -0.11$$

$$\tan\theta p = \frac{-0.11}{2}$$

$$= -0.05$$

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

$$\theta p = -2.86$$

Now $\sigma x' = \frac{\sigma x + \sigma y}{2} + \frac{\sigma x - \sigma y}{2}\cos 2\theta + \tau xy \sin 2\theta$

$$\sigma x' = \left(\frac{-21.35+0}{2}\right) + \left(\frac{21.35-0}{2}\right)\cos 2(-2.88) + 1.26\{\sin 2(-2.86)\}$$

$$= -10.67 - 10.67(0.99) + 1.26(-0.09)$$

$$= -11.74 \text{ psi}$$

(17)

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

$$= \left(\frac{-21.35+0}{2}\right) - \left(\frac{21.35-0}{2}\right)\cos 2(-2.86) - (1.26)\sin(-2.86)$$

$$= -10.67 + 10.67(0.98) - 1.26(-0.08)$$

$$= -8.58 \text{ psi}$$

Shear Stress :-

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

$$\tan 2\theta_s = -\left(\frac{(21.35-0)/2}{\tau_{xy}}\right)$$

$$= -\left(\frac{-21.35-0}{1.26}\right)/2$$

$$\tan 2\theta_s = 8.47$$

(18)

$\tan\theta = 8.47/2 = 4.23$

$\theta_s = \tan^{-1}(4.23)$

$\theta_s = 76.69°$

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

$\tau_{xy} \cos 2\theta$

$= -\frac{(-21.35 - 0)}{2} \sin 2(76.69)$

$+ 1.26 \{\cos 2(76.69)$

$= 10.67(0.448) + 1.26(-0.89)$

$\tau_{x'y'} = \boxed{3.65}$

# Mohr's Circle :

Mohr's Circle Center Coordinates.

$$(h, k) = \left[\frac{\sigma x + \sigma y}{2}, 0\right]$$

$$= \left[\frac{-21.35}{2}, 0\right]$$

$$= [-10.67, 0]$$

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

$$= \left(\frac{-21.35}{2} - 0\right)^2 + (1.26)^2$$

$$= \sqrt{(-10.67)^2 + (1.26)^2}$$

Radius $= 10.67$