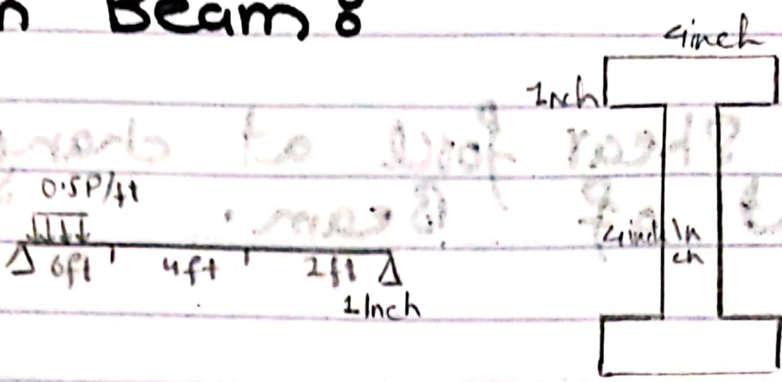
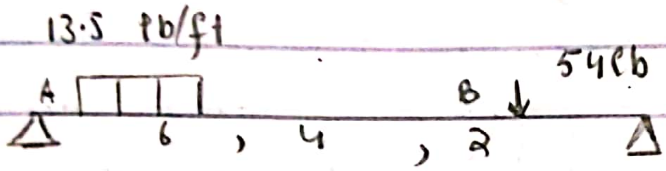
Q 1

Given Beam :



value of $P = 27$
So we have;



first unknown reaction find, at the support apply on equilibrium equation.

$\Sigma f_x = 0$ i-e $R = 0$
$\Sigma f_y = 0$

$R_1 + R_2 = (13.5 \times 6)\,lb + 54\,lb$
$R_1 + R_2 = 135$ —— ①

Next :

$\Sigma M_A = 0$
$R_2 \times 12 - 10 \times 54 - (13.5 \times 6) \times 3 = 0$
$12 R_2 = 540 + 243$
$12 R_2 = 783$
$R_2 = 65.25$

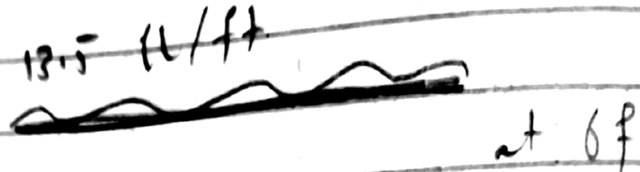
②

① $R_1 + R_2 = 135$

$\Rightarrow R_1 = 135 - 65.25$

$R_1 = 69.75$

Now Shear force at change point of Beam.



shear force at 6ft from support

$\Sigma f_y = 0$

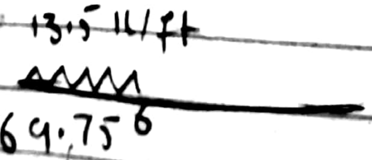
$69.75 - 13.5 \times 6 - V_{6ft} = 0$

$V_{6ft} = -11.25$

Now shear force at left

$\Sigma f_y = \oplus\uparrow \downarrow\ominus$

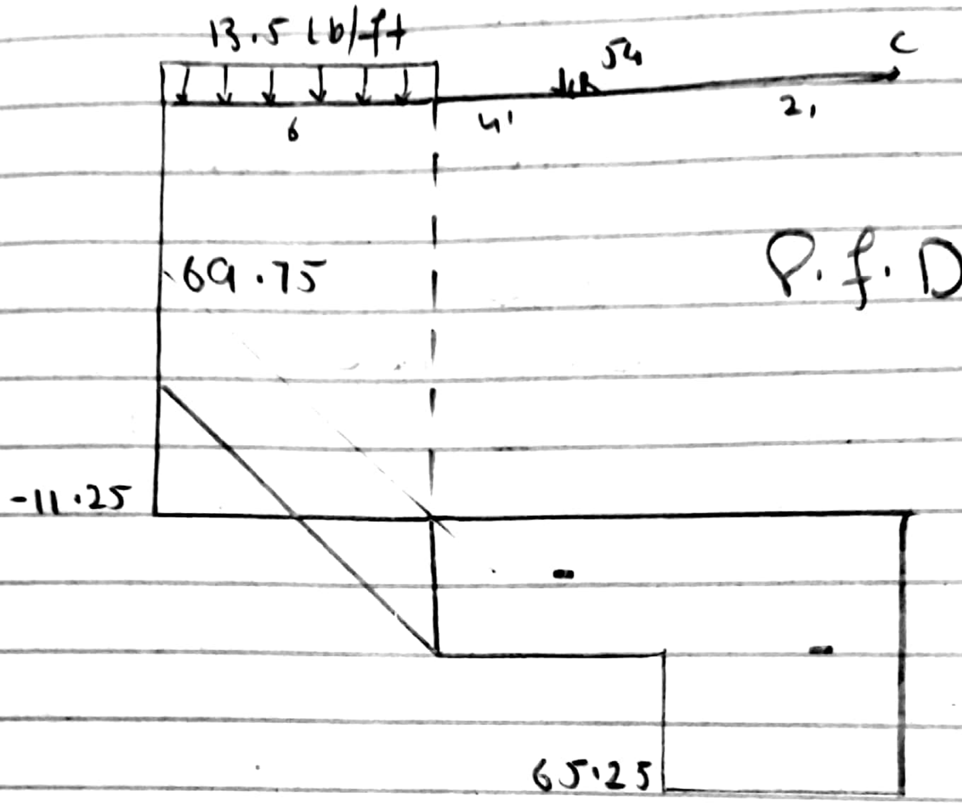
$\Rightarrow$



$= 69.75 - 13.5 - 54 - V_{10ft} = 0$

$V_{10ft} = -65.25$

Shear force and bending movement diagram.

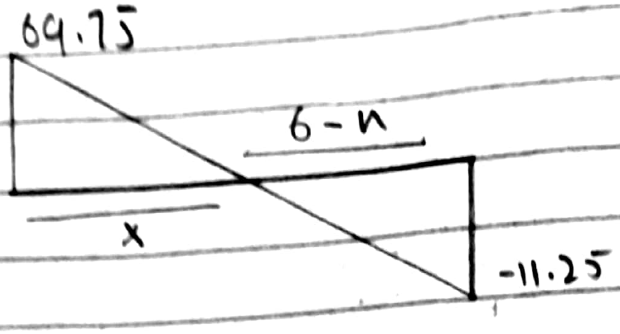


BMD

⇒ Point of maximum bending movement

As we know that the point where shear force point is maximum the bending movement is maximum so from point of zero shear corresponding point will have maximum bending movement.

from shear force diagram we have.



we know that

$$\frac{69.75}{x} = \frac{-11.25}{6-x}$$

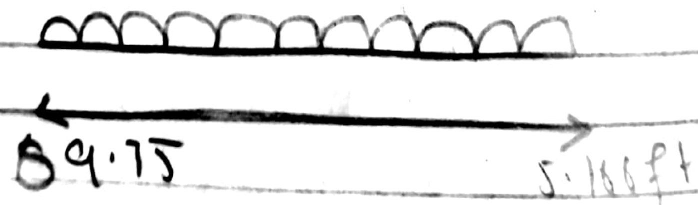
$$= 418.5 - 69.75x = -11.25x$$

$$418.5 = -11.25x + 69.75$$

$$418.5 = 81x$$

$$x = 5.16$$

Now determine the value of moment at 5.166ft



$$M_{5.166} - 69.75 \times 5.166 + \left(13.5 \times 5.166\right) \times \left(\frac{5.166}{2}\right) = 0$$

$$M_{5.166} - 360.32 + 69741 \times 2.583$$

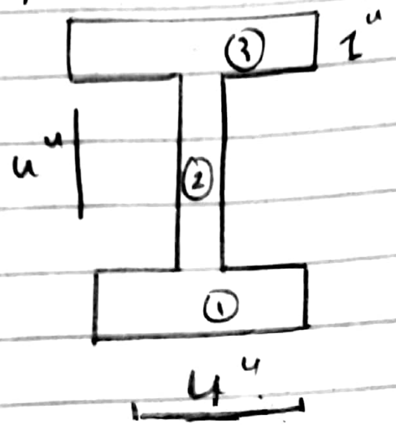
$$= -360.32 + 180141.003$$

$$= 180501.323 \text{ lbf}$$

⇒ For shear stress we have

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

Determine moment of Inertia I & Q the given section of Beam



As the give figure is symmetrical along both the axis.

So $\bar{x} = 4/2 = 2$ inch

$\bar{y} = 6/2 = 3$ inch

i-e $(\bar{x}, \bar{y}) = (2, 3)$

centre of gravity

extreme left and bottom

Area of point ① $= 4 \times 1 = 4\,inch^2$

Point ② $= 4 \times 1 = 4\,inch^2$

Point ③ $= 4 \times 1 = 4\,inch^2$

Moment of inertia about x-axis (centroid I) I_{xx}

Determine Distance b/w

C.G of the whole section and corresponding parts

let G_1, G_2, G_3 be in the centre of Gravity of Point ① ② & ③ and K_1, K_2, K_3 be the distance b/w $\bar{y}$ and y_1, y_2, y_3 respectively.

Sol

$K_1 = \bar{y} - y_1 = 3 - 0.5 \Rightarrow 2.5$ inch

$K_2 = \bar{y} - y_2 = 3 - 3 \Rightarrow 0$ inch

$K_3 = \bar{y} - y_3 = 3 - 0.5 \Rightarrow 2.5$ inch

So, $I_{xx} = \frac{b_1 h_1^3}{12} + a_1 K_1^2 + \frac{b_2 h_2^3}{12} + a_2 K_2^2$

$+ \frac{b_3 h_3^3}{13} + a_3 K_3^2$

$I_x = \frac{(4)(1)^3}{12} + 4(2.5)^2 + \frac{(1)(4)^3}{12}$
$+ a_2(0) + \frac{4(1)^3}{12} + 4(2.5$

$I_{xx} = \frac{4 + 12(2.5) + 64 + 4 + 12(2.5)}{12}$

$I_{xx} = 56$ inch

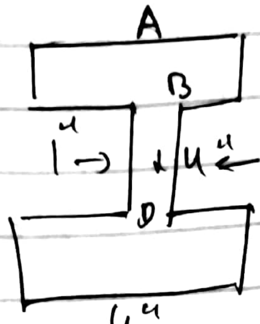
Now

$I_{yy} = \frac{b_1^3 h_1}{12} + \frac{b_2^3 h_2}{12} + \frac{b_3 h}{12}$

$$I_{yy} = \frac{64+4+64}{12} = 11 \text{ inch}^4$$

Next find the shear stress at various point we have

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



(1) shear stress at point "A" i.e At the top fiber

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

~~V~~ $V_{max} = 65.25$

$I = 67$

so, $\tau = \frac{65.25(0)}{67(4)}$

$\tau = 0$

(2) shear stress at point B

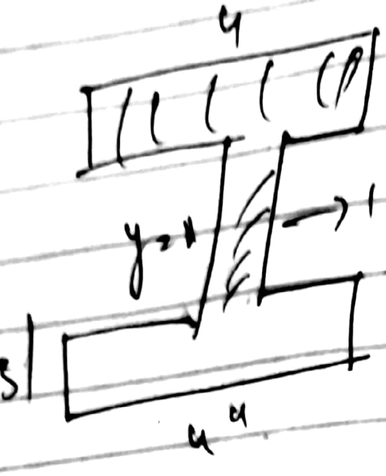
$$\tau = \frac{VQ}{Ib}$$

$$\tau = \frac{65.25 \times (4 \times 1)(3 - 0.5)}{67 \times 4}$$

[redacted]

$\tau = 782.97 \text{ lb/in}^2$

Shear stress at Point
i.e at N.A



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

$\frac{65.25 \times [4 \times 1 (3-0.5) + (1 \times 2)(2.}{67 \times 1}$

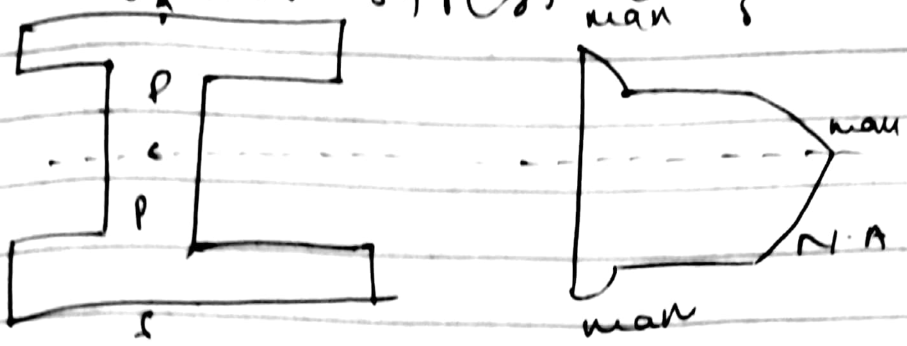
$I = 786.48$

(4)

Shear Stress at Point
D and E will the
because same Neutral axis and
of sym- maximum value at the
etry top of the section.

(9)

shear stress diagram



flenure stress determination

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

① flenure stress at the top fiber Point A

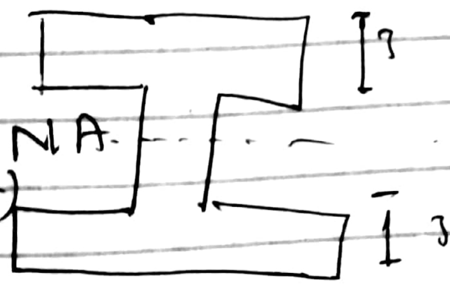
$$f = \frac{My}{I}$$

$$f = \frac{180501.32 \times 3}{67}$$

$$f = 8082.14$$

② flenure stress point (B)

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



$$f = 180501.\cancel{32}\,(3-0.5)$$

$$f = 541{,}503.95 \ lb/in^2$$

(3) flexure stress at point "C"

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

$$S = \frac{180501.32 \times (3-1)}{67}$$

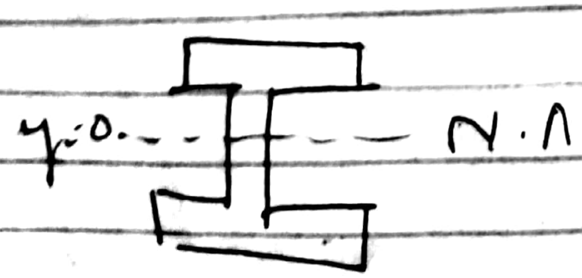
$$S = 541,503.94$$

(4) flexure stress at neutral axis (N.A)

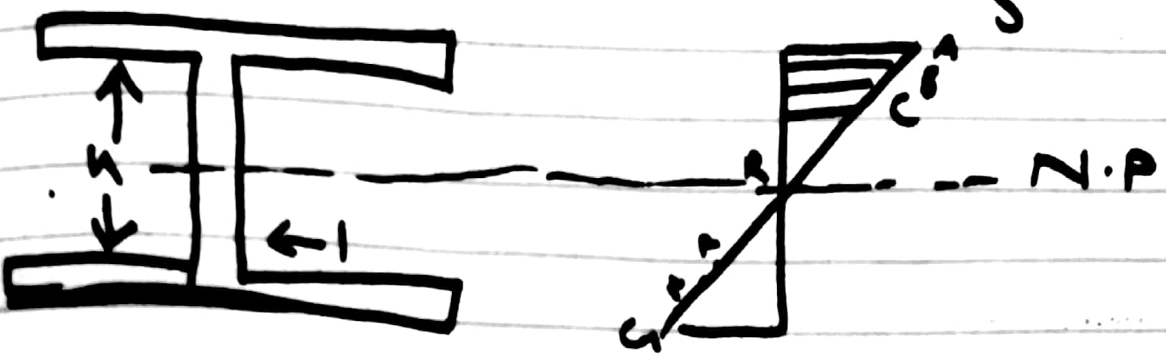
$$S = \frac{My}{I}$$

$$S = \frac{180501.32 \times 0}{64}$$

$S = 0$ lb/in



Flenure stress diagram



Stress State:

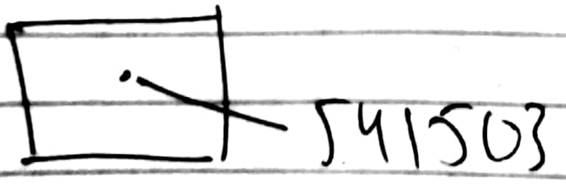
find stress state of point element located 3ft from left support and 1inch below from top fiber.

at point "c".

$\sigma = 541503$ psi

$\tau = 34.29$ psi

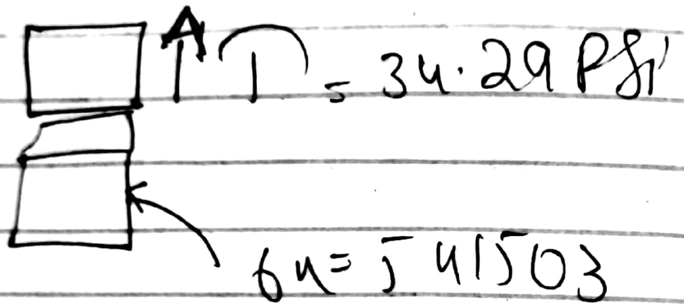
cosider point "C" is a planner element



{Normal stress}

$\tau = 34.29$ Psi is comperative Because Point "C" lies in compression zone of Beam cross section.

If Point C lies below the centried them stress would be tensile.



⇒ combine stress on 2nd element.

⇒ Find it Principle stress:

We have also find

$\sigma_n = 1\ldots 541503$

$\sigma_y = 0$

$\tau_{xy} = 34.29$

⇒ Principle stress equation:

$$\sigma_{xy_1} = \frac{\sigma_x + \sigma_y}{2} \pm \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right) + \tau_{xy}^2}$$

$$\sigma_{x_1 y} = \frac{-541503 + 0}{2} \pm \sqrt{\left(\frac{-541503}{2}\right)^2 (34.29)^2}$$

$$\sigma_{x_1 y} = -270751 \pm \sqrt{270420.08}$$

$$-270751 \pm 520.01$$
$$= -270230.99$$

Or first find $\theta_P = ?$

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

$$\tan 2\theta_P = -\frac{34.29}{541503/2}$$

$$\tan 2\theta_P = 0.0000833$$

$$\theta_P = 0.00001104\,8$$

Put in general equation

$$\sigma_{max} = \frac{-541503}{2} + \frac{-541503}{2}$$
$$\cos 2(-0.00001104\,8) + 34.29$$
$$\sin 2(-37.29)$$

σ_{Pmax}

$$-270751.5 - 270751.5$$
$$-32.74$$
$$\sigma_{max} = -541535.34$$

Max in Plane shear stress
in this case

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

$\tan\theta_s = \dfrac{541503/2}{34.29}$

$\tan 2\theta_s =$

$2\theta_s = \tan^{-1} 7895.971$

$\theta_s = \dfrac{15.10}{2}$

$\theta = 7.55$

Put in these general equations.

$\tau_{x'y'} =$ [redacted]

$= \left(\dfrac{541503 - 0}{2}\right)$

$(7.55) + 34.29$

$\cos 2(7.55)$

(270751.5)

$\tau_{x'y'}$ $\boxed{[redacted].32}$

1a) Draw Mohr's circle centre co-ordinate.

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

$= \left(\frac{541503}{2}, 0\right)$

$\Rightarrow (-946, 0)$

Radius of Mohr's circle

$r = \sqrt{(\sigma_x/\sigma_y + \tau_{xy}^2} = \sqrt{\left(\frac{541503-0}{2}\right)^2 (34.29)^2}$

$r = \boxed{1285.2941}$

Scale
1Psi = 1cm