NAME = Talha khan

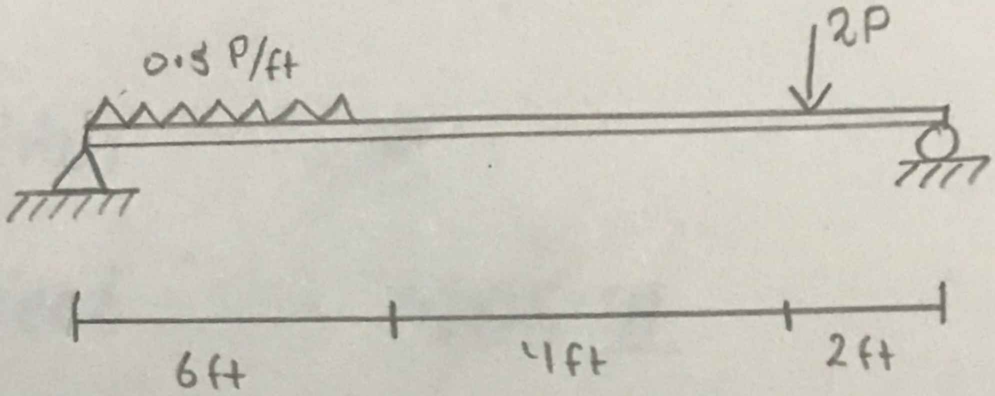
ID = 7982

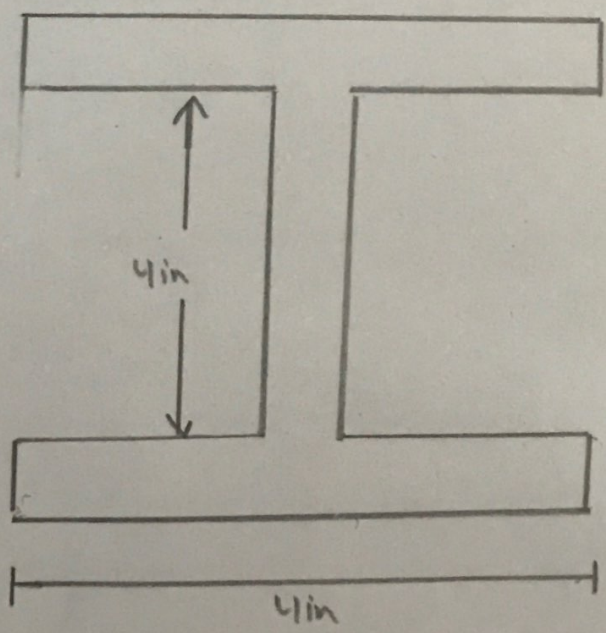
Section = B

Subject = MOS II

Question # 01

Free body diagram :





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Solution:

First of all we find Reactions. where a p value is my ID = 82lb

$0.5 \times 82 lb/ft = 41 lb/ft$

$2 \times 82 lb/ft = 164 lb/ft$

$\Sigma f_y = 0 \uparrow +$

$R_A + R_B - (41 \times 6) - 164 = 0$

$\boxed{R_A + R_B = 410 lb}$ — ①

$\Sigma M = 0$

$(R_B \times 12) - (164 \times 10) - (41 \times 6 \times 6/2) = 0$

$12 R_B = 1640 + 738$

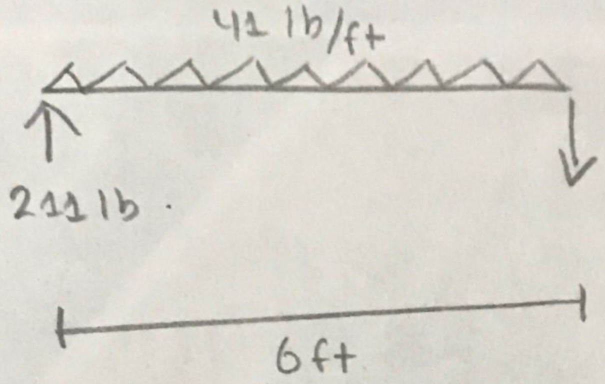
$R_B = 198.16 lb$

Now, put (R_B) in eq ①

$R_A = 410 - 198.16$

$R_A = 211.84 lb$

Now we will draw shear force and bending moment diagram - Shear force at change point or beam.



Shear force at 6ft from left support

$\Sigma F_y = 0 \uparrow +$

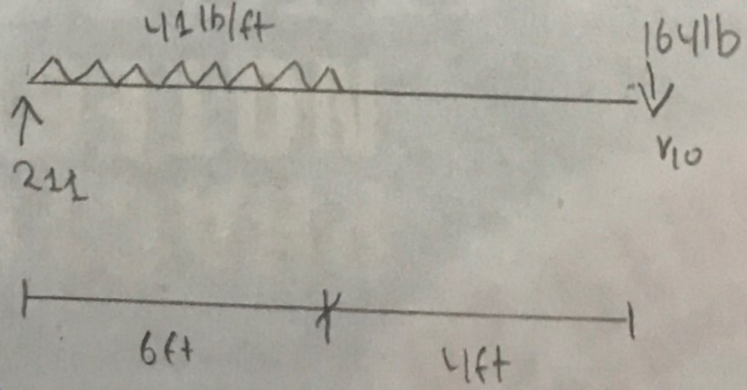
$-V_{6ft} + 211 - 41 \times 6 = 0$

$-V_{6ft} + 211 - 246 = 0$

$\boxed{V_{6ft} = -35 \text{ lb}}$

Now Shear force at 10ft from left

$V_{10} = ?$



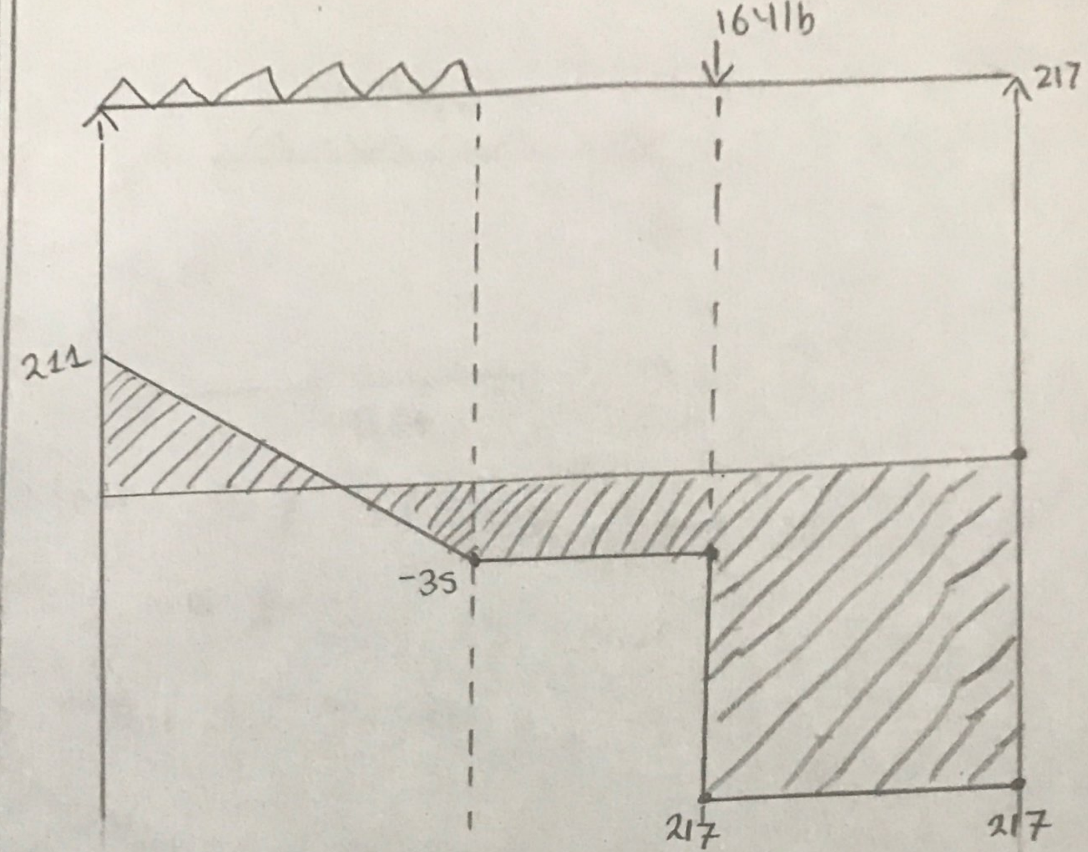
$\Sigma F_y = 0 \uparrow +$

$211 - (41 \times 6) - 164 - V_{10ft} = 0$

$211 - 264 - 164 - V_{10ft} = 0$

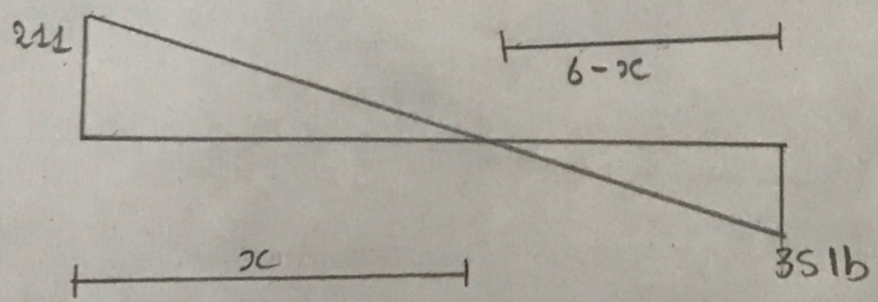
$-217 - V_{10ft} = 0$

$\boxed{V_{10ft} = -217 \text{ lb}}$



Now for moment diagram we find moment at change point.

First, finding moment at zero shear point



$$\frac{211}{x} = \frac{35}{6-x}$$

$$(211)(6-x) = 35x$$

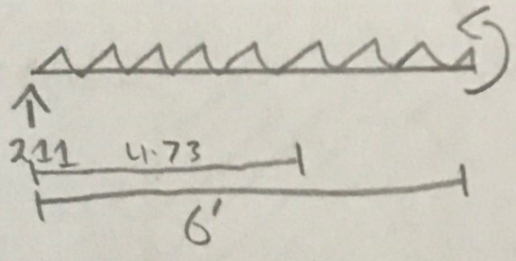
$$1266 - 211x = 35x$$

$$x = 4.739 \text{ ft}$$

As we know that moment is maximum where Shear force is zero

Taking section at 4.73 ft from left support and find moment.

$$\Sigma M_{4.73} = 0 \; (+)$$



$$0 = M_{4.73} - 211 \times 4.73 + 41 \times 4.73 \times \frac{4.73}{2}$$

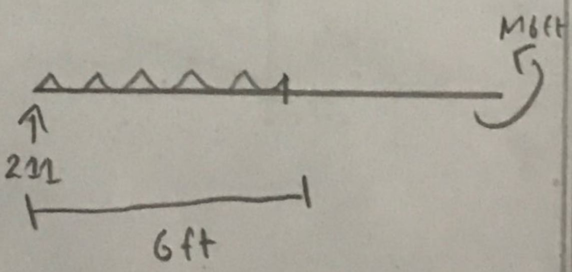
$$M_{4.73} = 998 + 458.64 = 0$$

$$M_{4.73} = 998 - 458$$

$$M_{4.73} = 540 \text{ lb-ft}$$

Moment at 6ft from left side

$$\Sigma M_{6ft} = 0 \; (+)$$



$$M_{6ft} - (211 \times 6) + (41 \times 6 \times 6/2) = 0$$

$$M_{6ft} = 528 \text{ lb-ft}$$

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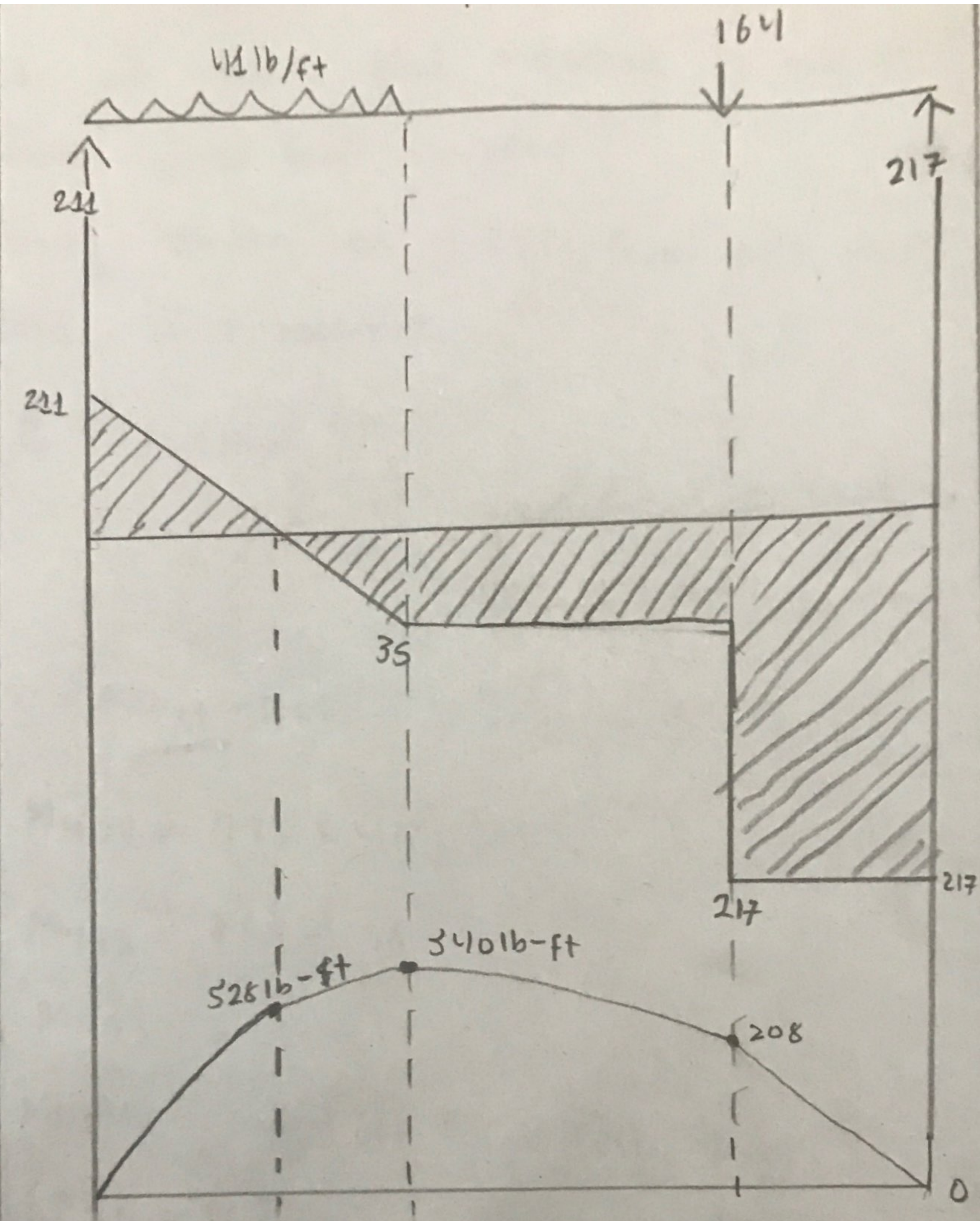
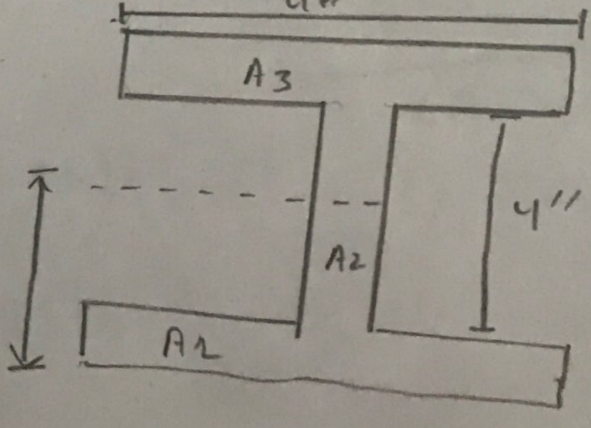


Now we find moment of inertia of the section



$\bar{y} = 3''$

$\bar{y} = 3''$

As we Now the Section is symetric

$\bar{y} = 1 + \cancel{4}^{2}/\cancel{2}$

$\bar{y} = 3in$

Now $I_x = \Sigma\left[I + Ad^2\right]$

$I_x = \left[I_1 + A_1 d_1^2\right] + \left[I_2 + A_2 d_2^2\right] + \left[I_3 + A_3 d_3^2\right]$

$I_x = \left[\frac{4\times1^3}{12} + (4\times1)(2.5)^2\right] + \left[\frac{1\times4^3}{12} + 1\times4(0)^2\right]$

$+\left[\frac{4\times1^3}{12} + (4\times1)(2.5)^2\right]$

$I_x = (0.33 + 25) + (5.33) + (0.33 + 25)$

$I_x = 56\,in^4$

Now we will calculate shear stress & flexural stress at different point in the beam.

for shear stress

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

$V_{max} = 217\ lb$

$I = 56\ in^4$

Case #1

τ at top fiber

$$\tau_{top\ fiber} = \frac{VQ}{Ib}$$

$$\Rightarrow \frac{217 \times 0}{56 \times 4} = 0$$

$\tau_{top\ fiber} = 0$

Case #2

τ at 1 in below the top fiber Two case A and B

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

$$\tau_A = \frac{217 \times (4 \times 1)(2.5)}{56 \times 4}$$

$\tau_A = 9.68$

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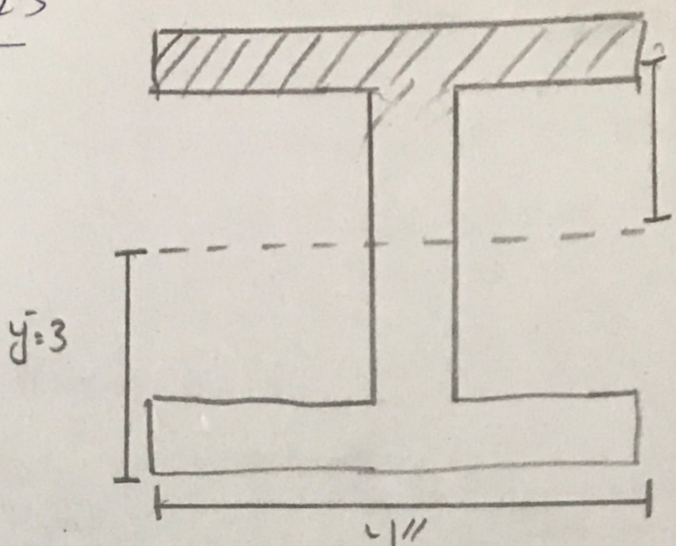
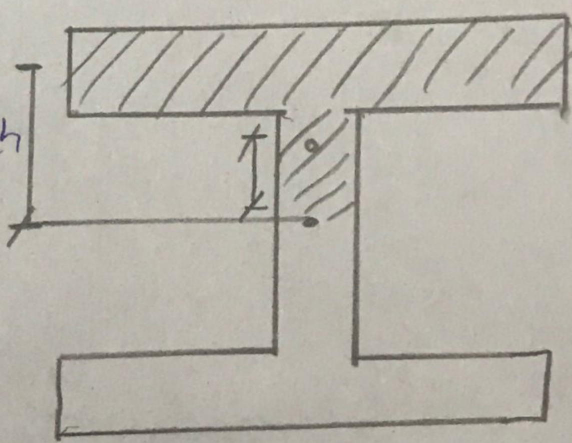
$$\tau_B = \frac{217 \times 4 \times 1 \times 2.5}{56 \times 1}$$



$$\tau_B = 38.75 psi$$

Case #3

τ at centrodial axis of the Section which will be the max Shear Stress



Here $Q = Q_1 + Q_2$

$Q = A_1 y_1 + A_2 y_2$

$= (4 \times 1)(2.5) + (2 \times 1)(1)$

$Q = 10 + 2$

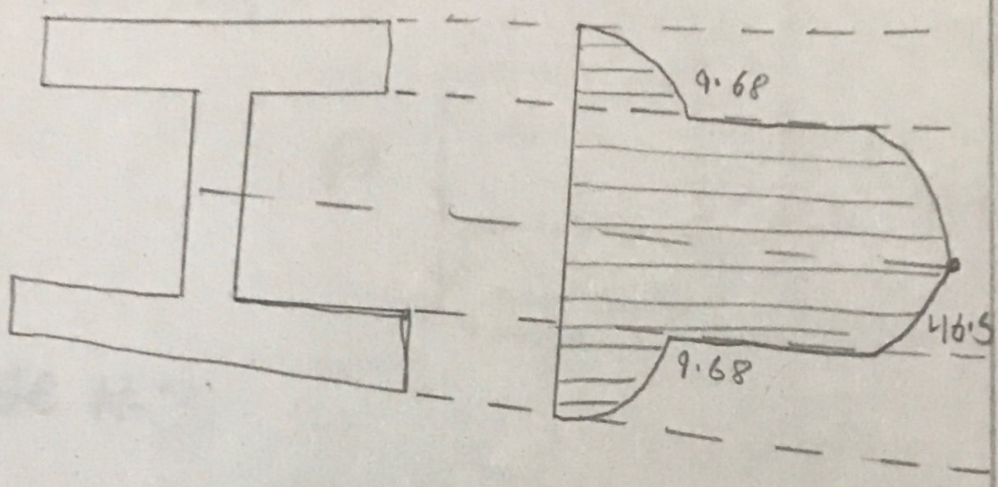
$Q = 12$

Now $\tau_{max} = \dfrac{217 \times 12}{56 \times 1}$

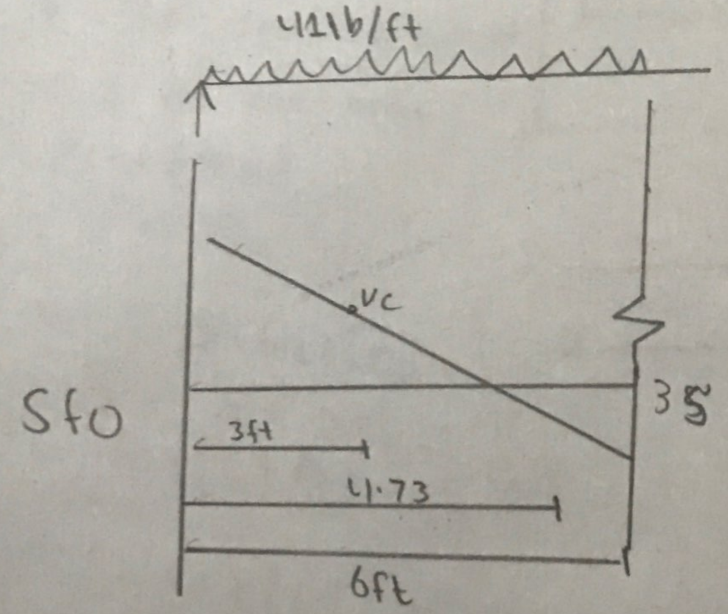
$\tau_{max} = 46.5$ Psi

The rest of the section is symetrical as above

Shear stress variation diagram along the depth of beam



Now Shear stress at point C is



$$\frac{V_c}{3} = \frac{211}{4.73}$$

$$V_c = \frac{211 \times 3}{4.73}$$

$$V_c = 133.32\,lb$$

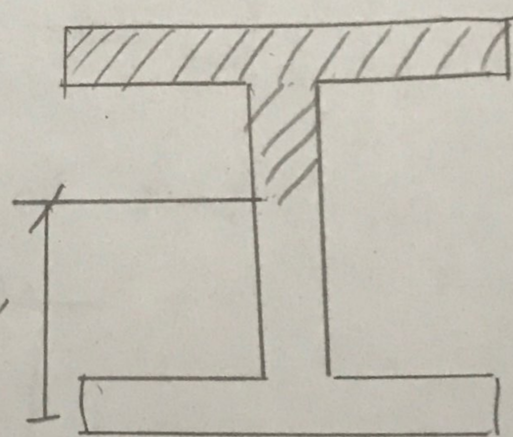
"T" at point "C" and 1in below the top fiber is

$$T_c = \frac{V_c Q}{Ib}$$

we will take $b = 1''$ to get figure value of T_c

$$T_c = \frac{133.82\,lb \times 4 \times 1 \times 2.5}{56 \times 1}$$

$$T_c = 23.89\,psi$$



Now Flexural Stress Analysis

we consider maximum moment from BMD

Maximum moment = 5410 lb-ft

Flexural stress ; $\sigma = \frac{My}{I}$

Case #1

Stress at top fiber

$$\sigma = \frac{540 \times 12 \times 3}{56}$$

$$\sigma_{Top} = 347.14$$

Case #2

Stress at 1" below Top fiber

$$\sigma = \frac{540 \times 12 \times 2}{56}$$

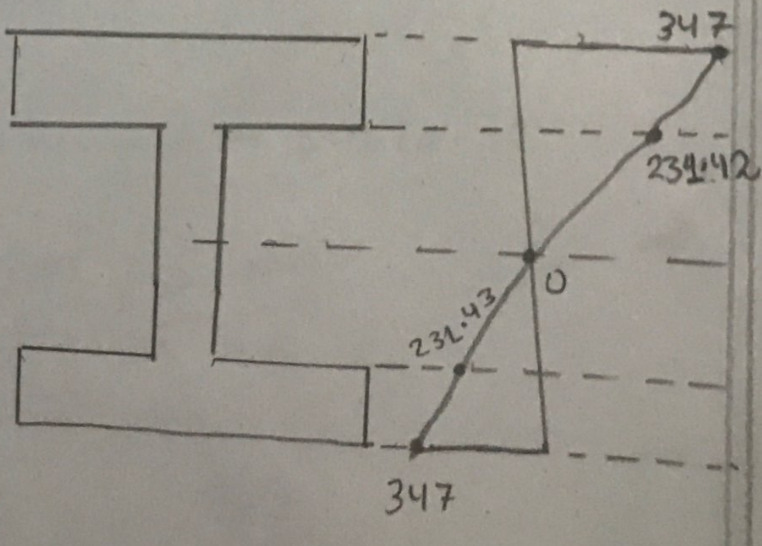
$$\sigma = 231.42$$

Case #3

Stress at centroidal axis

$$\sigma = \frac{540 \times 12 \times 0}{56}$$

$$\underset{center}{\sigma} = 0$$



Stress state of a point element

Now the stress state of a point element located at the center uniformly distributed load and 1" below the top fiber of beam cross section.

All applied stress are required at point C

we have found that shear stress at poin the required point which is $\tau_c = 23.89 Psi$

Flexural stress at required point is

$$\sigma_c = \frac{McY}{I}$$

moment at C is approximately the area under the shear force diagrams

$$Mc = [3 \times 84.95] + \left[\frac{3 \times 64.51}{2}\right]$$

$$Mc = 254.85 + 96.76$$

$$= 350 lb-ft$$

$$\sigma_c = \frac{350 \times 2 \times 12}{56}$$

$$\sigma_c = 150 lb/in^2$$

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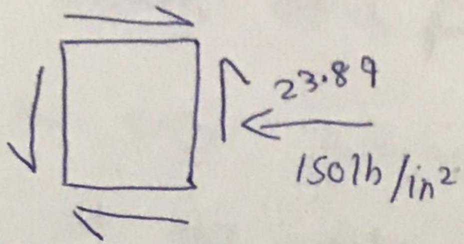
Combine stress on 2D element



Principal of stress:

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

$$= \frac{150 + 0}{2} \pm \sqrt{\left(\frac{150 - 0}{2}\right)^2 + (23.89)^2}$$

$$= -75 \pm \sqrt{5625 + 570.73}$$

$$= -75 \pm \sqrt{6195.73}$$

$$= -75 \pm 78.71$$

$\sigma_y = \sigma_1 = 3.71$ Psi

$\sigma = \sigma_2 = 153.71$ Psi

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Max in Plane shear stress

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

$$\tan 2Q = -\left(\frac{-150-0}{23.8}\right)/2$$

$$Q = 36.32^\circ$$

As General equation of $\tau_{x'y'}$

$$\tau_{x'y'} = -\left[\frac{\sigma_x - \sigma_y}{2}\right] \sin 2Q + \tau_{xy} \cos 2Q$$

$$= \left(\frac{-150-0}{2}\right) \sin 2(36.32) + 23.8 \cos(36.23)$$

$$\tau_{xy}' = 75.36 \, Psi$$

max in plane stress

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Center coordinate

$$(h, k) = \left[\frac{150+0}{2}, 0\right]$$

$$= [75, 0]$$

Radius of Mohr circle is

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

$$r = \sqrt{\left(\frac{150-0}{2}\right)^2 + (23.8)^2}$$

$$r = 78.1 \text{ Psi}$$