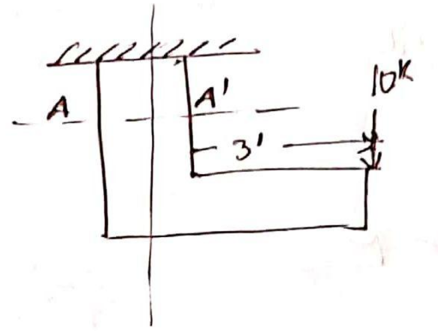
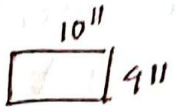
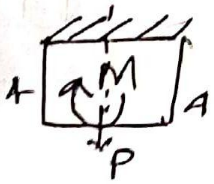
ger-907

01. Draw the stress diagram of section AA'







Solution:

Axial stress, $\sigma_a = \frac{P}{A} = \frac{10000}{10 \times 4} = 250$ psi

Flexural stress, $\sigma_f = \pm \frac{Mc}{I} = \frac{10 \times 10^3 \times (\frac{10}{2} + 3 \times 12) \times 10/2}{\frac{4 \times 10^3}{12}}$

$= \pm 6150$ psi

$\therefore$ stress at A,

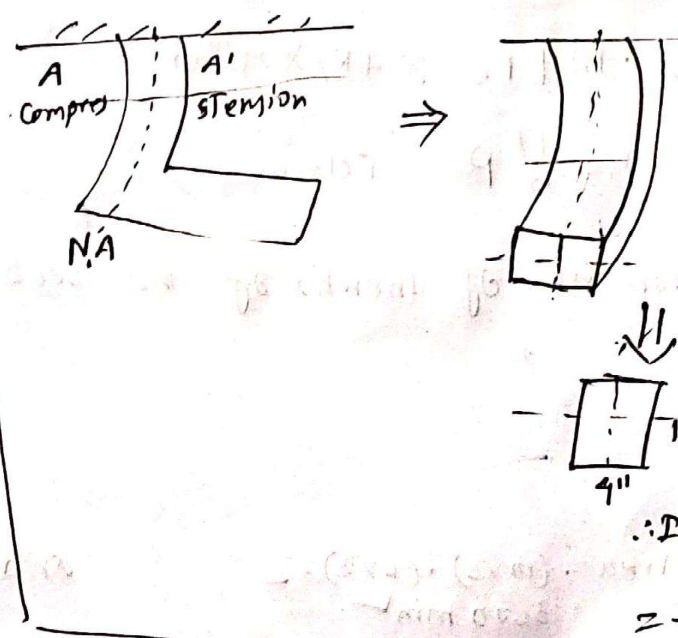
$\sigma_A = \sigma_a - \sigma_f$

$= 250 - 6150 = -5900$ Psi

Stress at A',

$\sigma_{A'} = \sigma_a + \sigma_f$

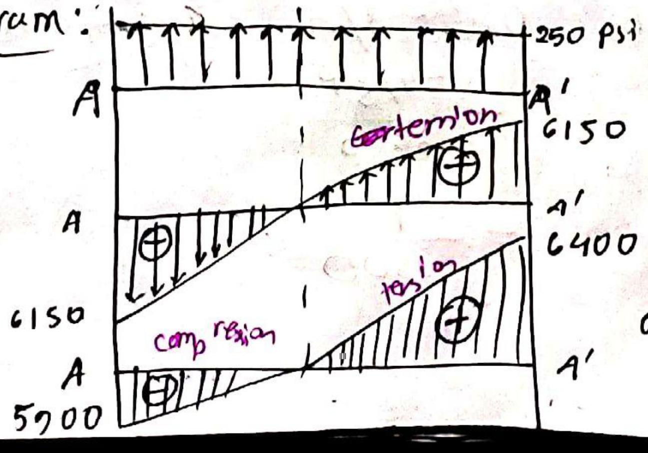
$= 64000$ Psi



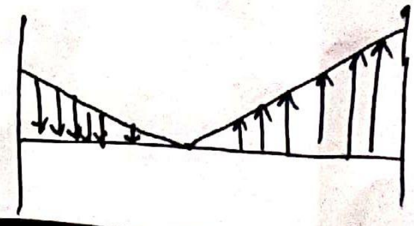
$\therefore I = \frac{bh^3}{12}$

$= \frac{4 \times 10^3}{12}$

stress Diagram:

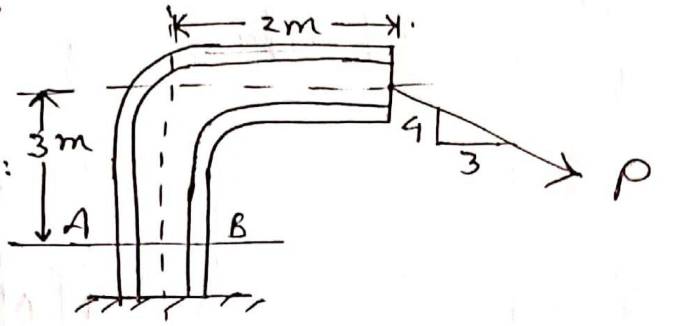


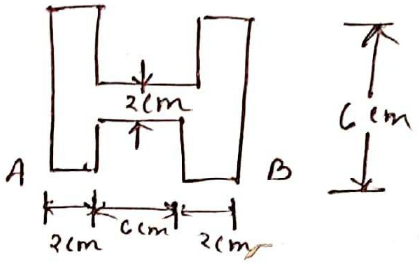
or



021 Determine the maximum load P that can be applied to the crane boom so that the normal stress on the section AB is limited to 80 MPa. [2008

~~Solution:~~





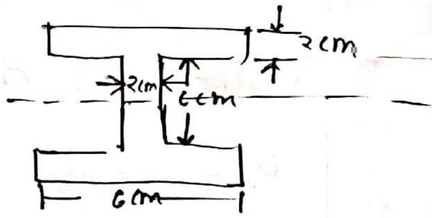
Solution:

Here, $P_x = \frac{3}{5}P$, $P_y = \frac{4}{5}P$

$\therefore \Sigma M = 0,$

$\Rightarrow -M + P_x \times 3 + P_y \times 2 = 0$

$\therefore M = \frac{17}{5}P$ (clockwise)



Moment of Inertia of the section,

$$I = \frac{2 \times 6^3}{12} + 2\left[\frac{6 \times 2^3}{12} + (6 \times 2)\left(\frac{6}{2} + \frac{2}{2}\right)^2\right]$$

$$= 428\,cm^3 = 428 \times 10^3\ mm^3$$

Area $= (10 \times 6) - (6 \times 2) \times 2$
$= 3600\ mm^2$

and, $c = 10/2 = 5\,cm = 50\,mm$

$\therefore$ Axial stress at AB, $\sigma_a = -P/A$ → Compression

$$= \frac{-4/5\,P}{3600}$$

$$= \frac{-P}{4500}$$

Flexural stress at AB, $\sigma_f = \pm \frac{Mc}{I}$

$$= \pm \frac{(17/5)P \times 50}{428 \times 10^3}$$

$$= \pm \frac{17P}{42800}$$

Stress at B, $\sigma_B = -\sigma_a - \sigma_f =$

$$\Rightarrow -80 = -\frac{P}{4500} - \frac{17P}{42800}$$

$\therefore P = 129153.39$ N

Stress at A, $\sigma_A = -\sigma_a + \sigma_f$

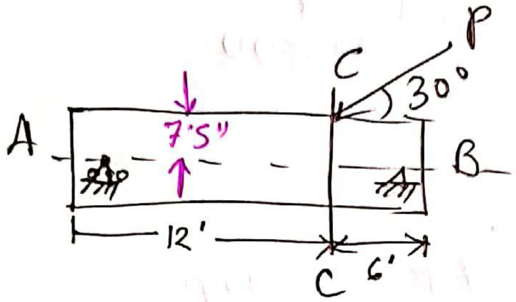
$$\Rightarrow 80 = -\frac{P}{4500} + \frac{17P}{42800}$$

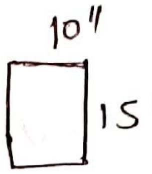
$P = 457.21$ kN

$\therefore$ safe load $P = 129.15$ kN

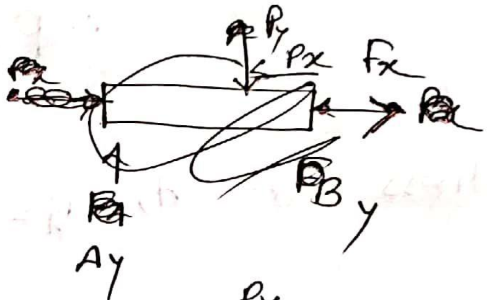
Styon205

Q31 - A wooden beam 10" × 15" is shown in figure below and carries a load P. What is the value of P if the maximum stress do not exceed 2000 psi? [2006]





Solution:

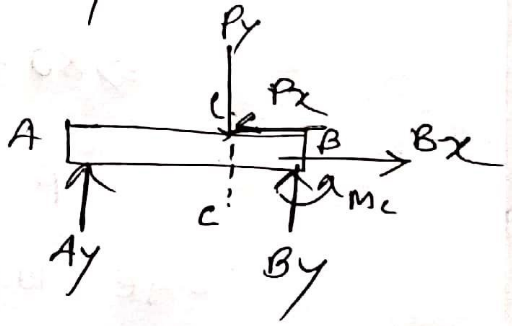


$P_y = P\sin 30$; $P_x = P\cos 30^\circ$

$\Sigma F_x = 0,$

$B_x - P_x = 0$

$\Rightarrow B_x = P_x = P\cos 30^\circ$



$\Sigma M_A = 0,$

$6 \times 18\, B_y + 7.5\, P\cos 30 - P\sin 30 \times 12 \times 6 = 0$

$$\therefore B_y = \frac{P(\sin 30 \times 12 \times 6 - 7.5\cos 30)}{18 \times 6}$$

$\Sigma M_C = 0,$

$$M_C = B_y \times 6 \times 12 = \frac{P(\sin 30 \times 12 \times 6 - 7.5\cos 30)}{18 \times 6} \times 6 \times 12$$

Axial stress, $\sigma_a = \dfrac{B_x}{A} = \dfrac{P\cos 30}{10 \times 15}$

Flexural stress, $\sigma_f = \dfrac{Mc}{I} = \dfrac{7.5M}{\frac{10 \times 15^3}{12}} = \dfrac{M}{375}$

At bottom, $\sigma = \sigma_A + \sigma_f$

$$= 72000 = \frac{P\cos 30}{150} + \frac{M}{375}$$

$$= \frac{P\cos 30}{150} + \frac{P[\sin 30 \times 12 \times 6 - 75\cos 30) \times 6 \times 12}{375 \times 18 \times 6}$$

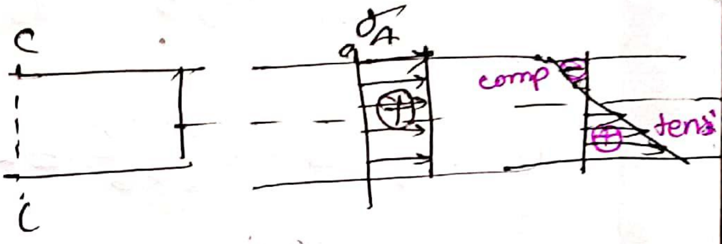
$\Rightarrow P = 34348.6$ psi

which is the largest load

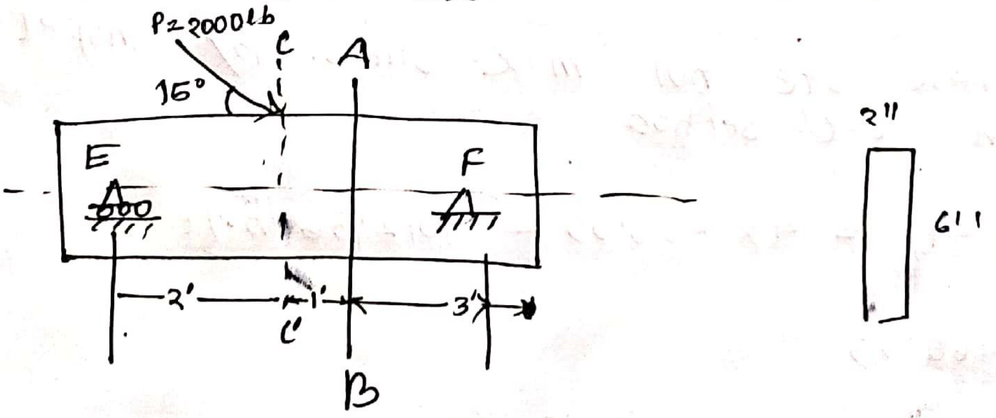
At top,

$\sigma = \sigma_A - \sigma_f$

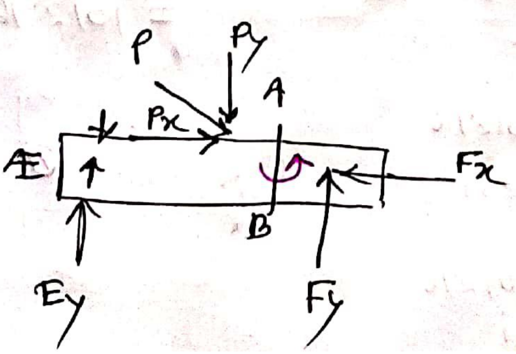
$\Rightarrow 2000 = P$



singer 906 | For 2"×6" wooden beam, determine the normal stresses at A and B. Are these these the points of maximum normal stress? If not where are they located and wat are their values?



Solution:



$\Sigma F_x = 0,$

$-F_x + 2000\cos 15^\circ = 0$

$\therefore F_x = 2000\cos 15^\circ$

$\Sigma M_E = 0,$

$+2000\sin 15^\circ \times 2 + 2000\cos 15^\circ \times \frac{3}{12} - F_y \times 6 = 0$

$\therefore F_y = 253.09$

At section AB,

$M_c = 3F_y$

$= 3\times 253.09 = 759.11$ lb

compression

$\therefore \sigma_a = \frac{-P}{A} = \frac{200\cos 15}{2\times 6} = -160.99$ psi

$\sigma_f = \frac{Mc}{I} = \frac{3\times 253.09 \times 12 \times 3}{\frac{2\times 6^3}{12}} = 759.11$ psi

$\therefore \sigma_A = -\sigma_a - \sigma_B = -160.99 - 759.99 = -920.10$ psi

$\sigma_B = -\sigma_a + \sigma_f = 598.12$ psi

No these are not max stress. By inspection these are in c-c' section

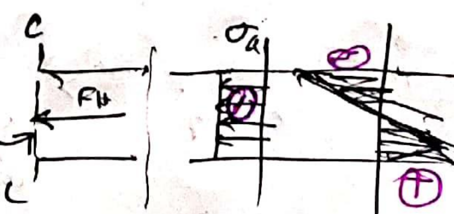
$M_C = 4F_y = 4\times 253.09 = 1012.36$ lb-ft

$\sigma_a = -160.99$

$\therefore \sigma_f = \frac{6M}{bd^2} = \frac{6\times 1012.36\times 12}{2\times 6^2} = 1012.16$ psi

$\sigma_C = -\sigma_a - \sigma_f = -160.99 - 1012.16$

$= -1173.15$ psi

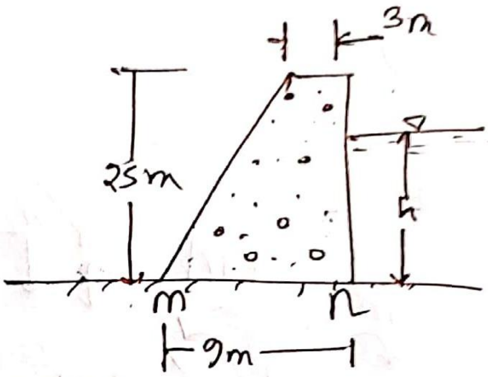


$\sigma_{C'} = -\sigma_a + \sigma_f = -160.99 + 1012.16$

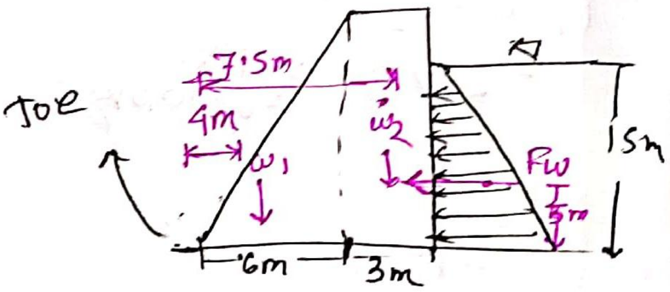
$= 851.17$ psi

911. A concrete dam has the profile shown in ~~profile~~ figure. If the density of concrete is 2400 kg/m³ and that of water is 1000 kg/m³, determine the maximum compressive stress on section m-n if the depth of water behind the dam is h = 15m

[2013, 2015, 2016, 2019



Solution



Rules for Gravity Dams:

i. Consider 1m length of dam (Perpendicular to the sketch)

ii. Determine all the forces:

A.

1. Weight of dam
2. " " water in upstream (if any)
3. Hydrostatic uplift

B. Horizontal force

1. Total Hydrostatic force acting at the vertical projection of the submerged portion of the dam

iii. Solve for the reaction

A. Vertical Reaction, R_y

B. Horizontal ", R_x

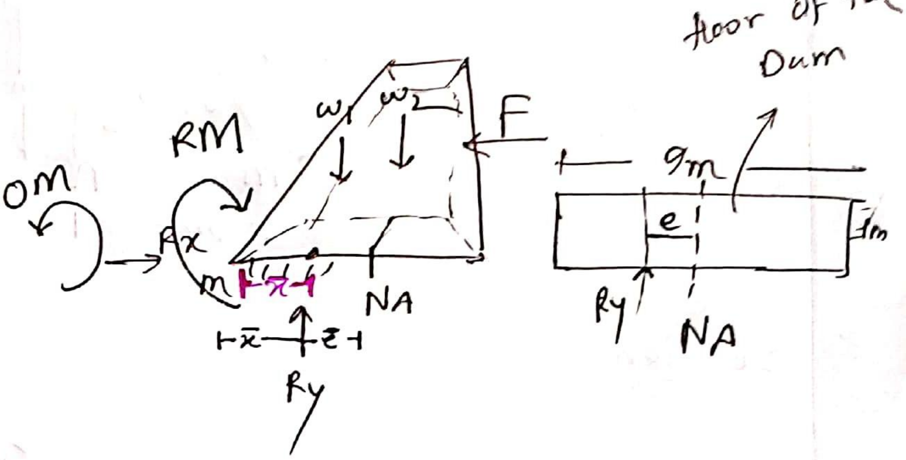
iv. Moment about the toe

A. Righting Moment, (RM)

B. Overturning, OM

V. Location of Ry ($\bar{x}$)

Solution:



$\Sigma f_y = 0$,

$R_y - W_1 - W_2 = 0$

$R_y = W_1 + W_2$

$= \frac{1}{2}(9+3) \times 25 \times 1 \times 2400$

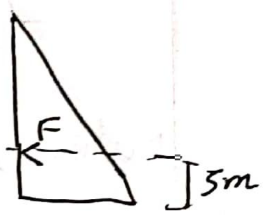
$= 360000 \text{ kg}$

$\Sigma F_x = 0$,

$R_x - F = 0$

$\Rightarrow R_x = F$

$= 1125000 \text{ kg}$



Pressure, $w = \gamma h = 1000 \times 15$

$= 15000$

$\therefore F = \frac{1}{2} wh = \frac{1}{2} \times 15000 \times 15$

$= 112500 \text{ kg}$

Moment about m,

(i) Righting moment

$RM = 4 \times W_1 \cancel{\times} 7.5 \times W_2$

$= 2070000 \text{ kg m}$

(ii) Overturing Momemt,

$OM = F_w \times 5 \cancel{+ R_y \times} = \cancel{5620} \; 562500 \text{ kg.m}$

Now for the dam to be static, moments about the toe 'm' needs to be equal and opposite they zero

∴ from all the moments about m, we get

$RM = OM + Ry \times \bar{x}$

$\Rightarrow \bar{x} = \dfrac{RM - OM}{Ry}$

$= \dfrac{2070000 - 562500}{4.1875m}$

∴ $e = 4.5 - 4.1875m = 0.3125m$

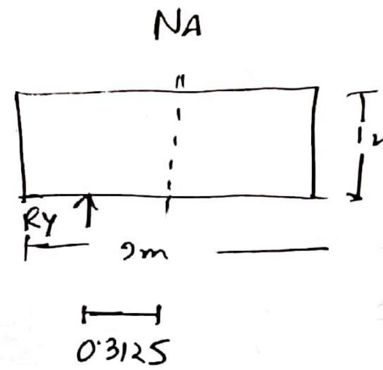


fig. Topview of dam base

Main Combined stress part:

$M = Ry \times e = 360,000 \times (0.3125)$

$= 112,500$ kg.m

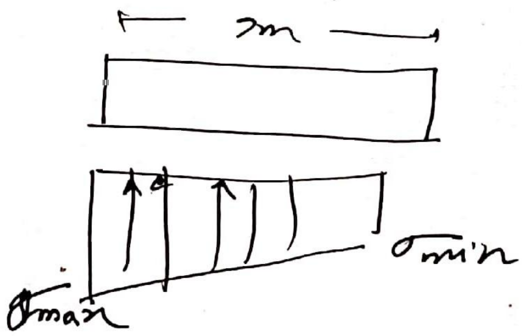
$\sigma_a = \dfrac{P}{A} = \dfrac{360000}{1\times 9} = 40,000 \, kg/m^2$

$\sigma_f = \dfrac{6M}{bd^2} = \dfrac{6(112,500)}{1(9)^2}$

$= 8333.33 \, kg/m^2$

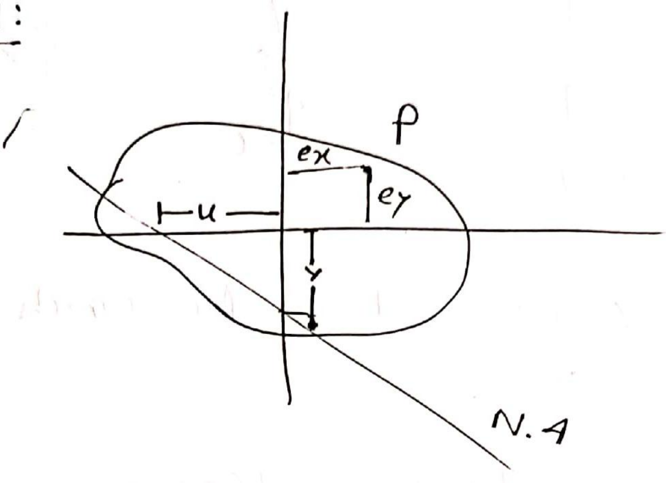
∴ $\sigma_{max} = \sigma_a + \sigma_f$

$= 48333.33 \, kg/m^2$



Kern

Determining N.A:



$(e_x, e_y) \rightarrow$ point of Load

$(x, y) \rightarrow$ point of zero stress

The stress at any point of the section,

$$\sigma = -\frac{P}{A} + \frac{(Pe_x)x}{I_y} + \frac{(Pe_y)xy}{I_x} \quad [(x,y) \text{ any point on N.A}]$$

We know N.A is the line of zero stress, thus, $\sigma = 0$

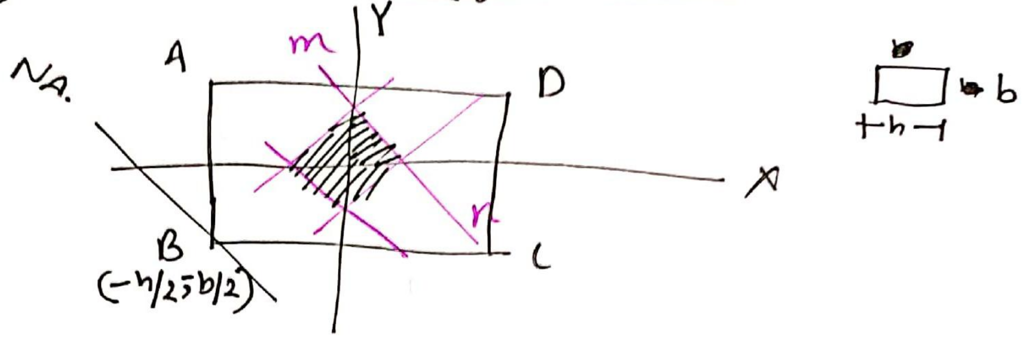
$$\therefore \sigma = 0 = -\frac{P}{A} * \frac{(Pe_x)x}{I_y} * \frac{(Pe_y)xy}{I_x}$$

$$\therefore 0 = 1 + \frac{e_x}{r_y^2} x + \frac{e_y}{r_x^2} y$$

$$\therefore \left(\frac{e_x}{r_y^2}\right)x + \left(\frac{e_y}{r_x^2}\right)y + 1 = 0$$

Ans!

(i) Determining kern of a rectangular section:



Let's e_x and e_y for load p for which the neutral axis passes through B.

we know,

$$\sigma = -\frac{P}{A} - \frac{(Pe_x)}{I_y}x - \frac{(Pe_y)}{I_x}y$$

At B, on N.A, $\sigma = 0$, $(x, y) \equiv (-h/2, -b/2)$

$$\therefore 0 = -\frac{P}{bh} + \frac{P\,e_x}{bh^3/12} \times h/2 + \frac{Pe_y}{hb^3/12} \times b/2$$

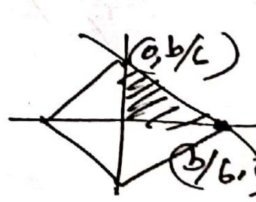
$$\Rightarrow \quad 0 = \boxed{\frac{e_x}{h/6} + \frac{e_y}{b/6} = 1}$$

This is the equation of a straight line mn.

" This line is the locus of points of application of P for which at B stress is zero. "

(ii) Square section:

For square, $h = b$ $\therefore \frac{e_x}{b/6} + \frac{e_y}{b/6} = 1$



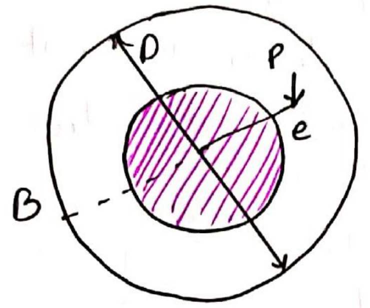
$\therefore$ Area of the kern section,

$$= \left\{\frac{1}{2} \times b/6 \times (b/6 + b/6)\right\} 2$$

$$= \frac{b^2}{18}$$

$\therefore$ The area of the kern of a section is 1/18th of the cross sectional area of a square

(iii) Kern of a Circular section:



Like before, for load at P, the point of zero stress wi at point B.

∴ Stress at B,

$$\sigma_B = -\frac{P}{A} + \frac{My}{I}$$

$$= \frac{-P}{\frac{\pi D^2}{4}} + \frac{(Pe) \times D/2}{\frac{\pi D^4}{64}} = -\frac{4P}{\pi D^2} + \frac{64PeD}{2\pi D^4}$$

Now, $\sigma_B = 0$

$$\Rightarrow -\frac{4P}{\pi D^2} + \frac{64PeD}{2\pi D^4} = 0$$

$\therefore e = D/8$

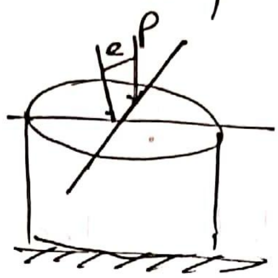
∴ Diameter of the kern of the section $= 2 \times e$

$$= 2 \times D/8$$

$$= \frac{D}{4}$$

$$= \frac{\text{Diameter of section}}{4}$$

* Determine the permissible eccentricity, as shown in the following figure, of a load P that acts on a 24" dia post; if the max tensile stress is not to exceed 10% of the permissive compressive strength. [2010]



Solution:

Dia = 24"

$$\sigma_T = -\frac{P}{A} + \frac{Mc}{I}$$

$$\sigma_C = -\frac{P}{A} - \frac{Mc}{I}$$

Now,

$$\sigma_T = 10\% \ \sigma_C$$

$$\Rightarrow -\frac{P}{A} + \frac{Mc}{I} = \frac{10}{100}\left(-\frac{P}{A} - \frac{Mc}{I}\right)$$

$$\Rightarrow \frac{-10P}{\frac{\pi D^2}{4}} + \frac{10Mc}{I} = -\frac{P}{\frac{\pi D^2}{4}} - \frac{Mc}{I}$$

$$\Rightarrow \frac{4\times 9P}{\pi D^2} = \frac{11Mc}{\frac{\pi D^4}{64}}$$

$$\Rightarrow \frac{36\cancel{P}}{\cancel{\pi}D^2} = \frac{64\times 11\times \cancel{P}\times e\times D/2}{\cancel{\pi}D^4}$$

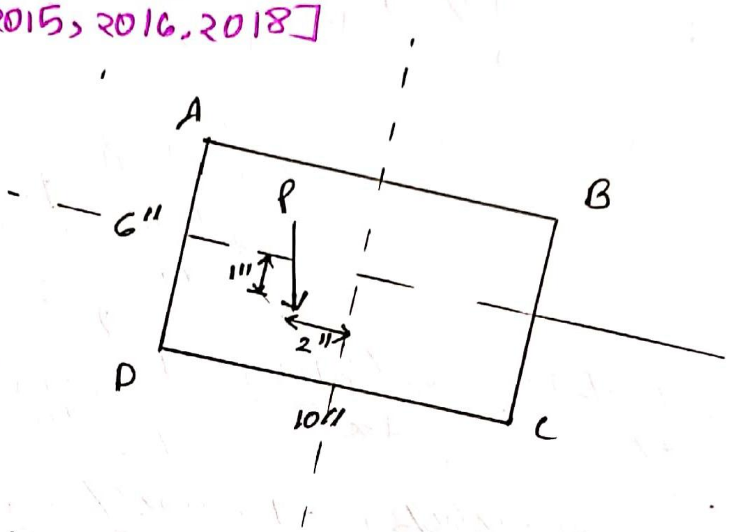
$$\Rightarrow e = \frac{36D}{11\times 32}$$

$$= \frac{36\times 24}{11\times 32} = 2.45 \text{ inch}$$

$\boxed{\text{Ans}}$

* A compressive load P=15000lb is applied as shown in figure below. Compute stress at each corner and the location of neutral axis.

[2012, 2013, 2015, 2016, 2018]



Here,

$P = 15000$ lb

$h = 6"$

$b = 10"$

$e_x = 2"$

$e_y = 1"$

$A = 10 \times 6 = 60 in^2$

$I_x = \frac{10 \times 6^3}{12} = 180 in^4$

$I_y = \frac{6 \times 10^3}{12} = 500 in^4$

$M_y = Pe_x = 15000 \times 2 = 30000$ lb.in

$M_x = Pe_y = 15000 \times 1 = 15000$ lb.in

The resultant stress at any point,

$$\sigma = -\frac{P}{A} \pm \frac{M_y \times b/2}{I_y} \pm \frac{M_x \times h/2}{I_x}$$

At point A,

$$\sigma_A = -\frac{P}{A} - \frac{M_y \times b}{I_y} + \frac{M_x \times h}{I_x} = -\frac{15000}{60} - \frac{30000 \times (10/2)}{500} + \frac{15000 \times (6/2)}{180}$$

$= -300$ Psi

$= 300$ Psi (c)

At point B,

$$\sigma_B = -\frac{P}{A} + \frac{M_y \times (b/2)}{I_y} + \frac{M_x \times (h/2)}{I_x}$$

$$= -\frac{15000}{60} + \frac{30000 \times (10/2)}{500} + \frac{15000 \times 6/2}{180}$$

$$= 300 \text{ psi } (T)$$

At point, c

$$\sigma_C = -\frac{P}{A} + \frac{M_y (b/2)}{I_y} - \frac{M_x (h/2)}{I_x}$$

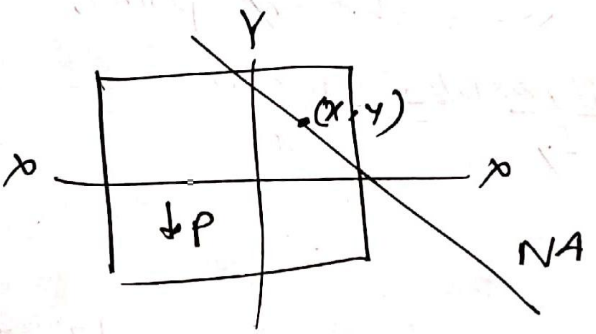
$$= -\frac{15000}{60} + \frac{30000 \times (10/2)}{500} - \frac{15000 \times 6/2}{180}$$

$$= -200 \text{ psi}$$

$$= 200 \text{ psi } (C)$$

At D,

$$\sigma_D = -P/A - \frac{M_y (x/2)}{I_y} - \frac{M_x (y/2)}{I_x} = -800 = 800 \text{ psi } (C)$$



For NA, any point (x, y)

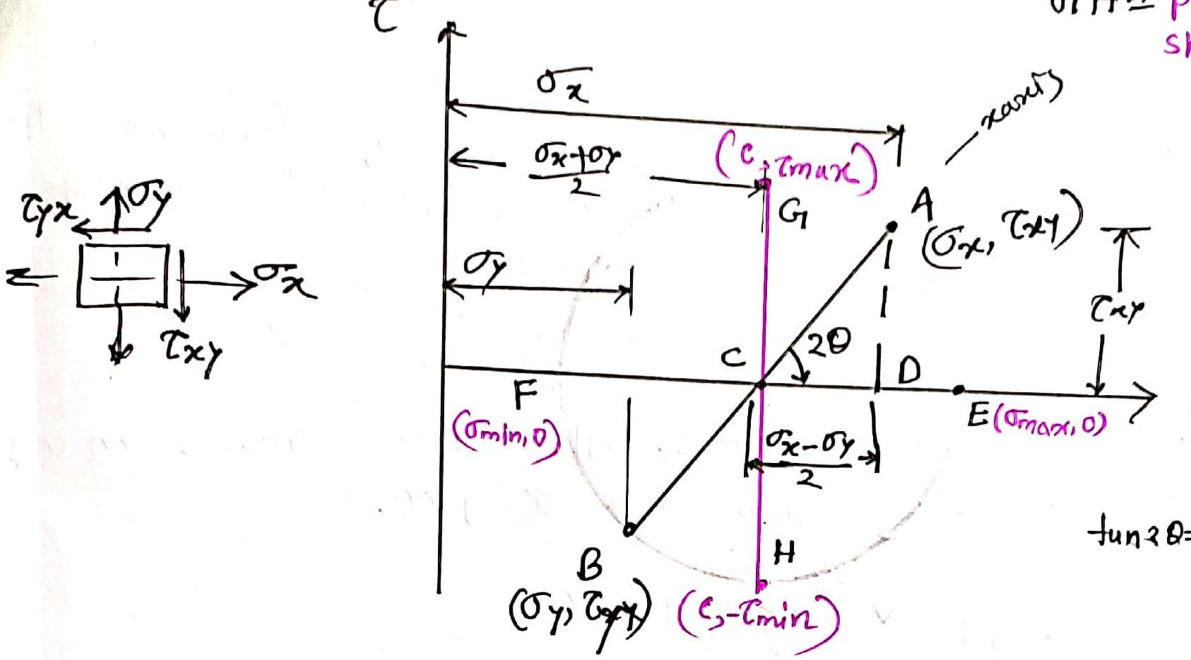
$$\therefore \sigma = -\frac{P}{A} + \frac{M_y \times x}{I_y} + \frac{M_x \times y}{I_x}$$

$$\Rightarrow 0 = -\frac{15000}{60} + \frac{30000\,x}{500} + \frac{15000\,y}{180}$$

$$\Rightarrow \boxed{0 = -250 + 60x + 83.33y}$$ Line of N.A

Moh'r's Circle

EF= Principal plane
GH= plane of max shearing stress



$$\tan 2\theta = \frac{\tau_{xy}}{\frac{\sigma_x-\sigma_y}{2}}$$

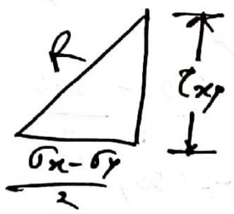
Max/Min Pricipal Stresses: $\sigma_{max}, \sigma_{min}$ (E, F)

Principle Stress: Thie maximum and minimum normal stress

Principle plane: The plane on which max and min normal stress act on, and shearing stress is zero.

Angle of principle plane/ zero shearing stress

$$\tan\theta = \frac{-2\tau_{xy}}{\sigma_x-\sigma_y}$$



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

$$\text{or } \tau_{max} = \frac{\sigma_x+\sigma_y}{2}$$

$$\tau_{min} = \frac{\sigma_x-\sigma_y}{2}$$

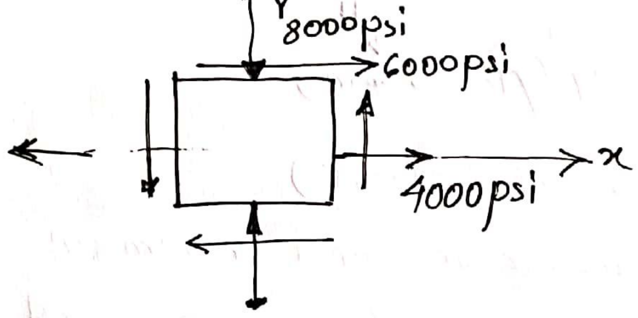
$$\sigma_{max} = C+R = \frac{\sigma_x+\sigma_y}{2} + \sqrt{\left(\frac{\sigma_x-\sigma_y}{2}\right)^2+\tau_{xy}^2}$$

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

~~9271 A state of stress in~~ figure, determine the principle stresses and the maximum in ~~plane shearing~~ stress. [2009, 2016]

~~9271 For the state of stress shown below, determine the principal stresses and the maximum~~ in-plane shearing stress. Show all results on complete

9261 Find the principal stress. Also the stresses on a plane at ~~60~~ 30° counterclockwise from the x face.



Solution:

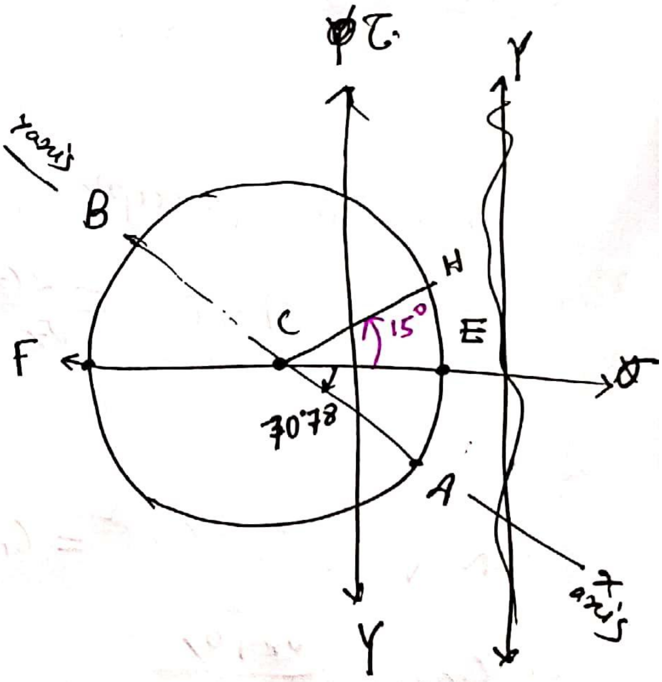
$\sigma_x = 4000\,psi$ $\tau_{yx} = +6000$

$\sigma_y = -8000\,psi$ $\tau_{xy} = -6000$

$\therefore A(\sigma_x, \tau_{xy}),\ B(\sigma_y, \sigma_{yx})$

$\therefore C = \frac{\sigma_x + \sigma_y}{2} = \frac{4000-8000}{2}$

$= -2000\,psi$



$\therefore R = \sqrt{\left\{\frac{4000-(-8000)}{2}\right\}^2 + (-6000)^2}$

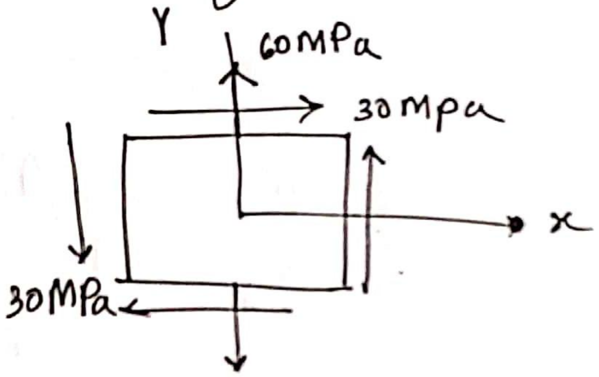
$\therefore R = 8485.28$

At E,

$\therefore \sigma_{max} = 8485.28 - 2000 = 6485.28$

$\therefore \sigma_{min} = -8485.28 - 2000 = -10488.85$

9271 Find the principal stresses and the maximum in plane shearing stress.

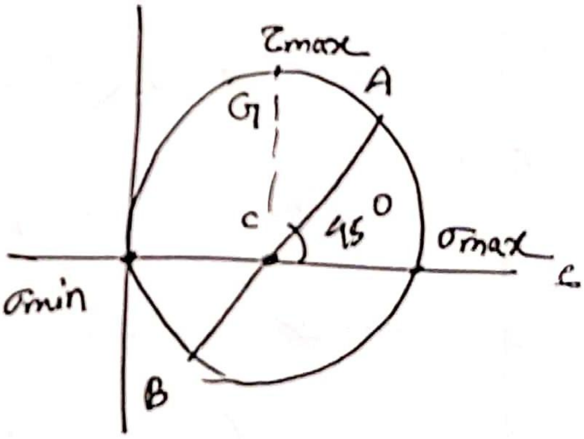


Solution:

$\sigma_x = 0$, $\tau_{xy} = -30$

$\sigma_y = 60$, $\tau_{yx} = +30$

$\therefore C = \frac{60+0}{2} = 30$



$R = \sqrt{\left(\frac{60}{2}\right)^2 + 30^2}$

$= 42.42$

$\therefore \sigma_{max} = 30 + 42.42$

$= 72.4$

$\sigma_{min} = 30 - 30\sqrt{2} = -12.426$

$\therefore \tan 2\theta = \frac{-2\tau_{xy}}{\sigma_x - \sigma_y}$

$= \frac{-2 \times 30}{0-60}$

$2\theta = 45^\circ$

$\therefore \theta = 22.5^\circ$

And $\tau_{max} = 42.42$ at point G

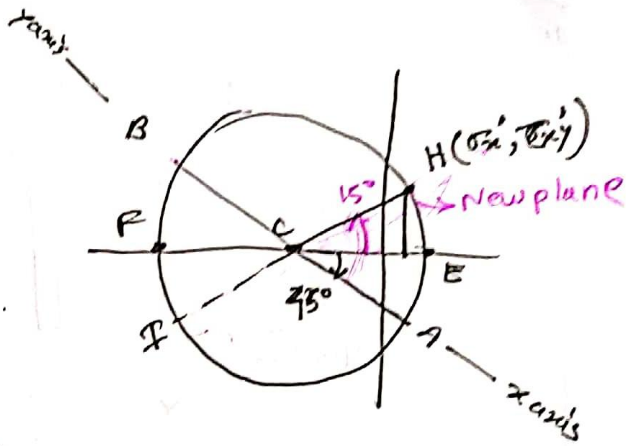
Now,

$\tan 2\theta = -\dfrac{2\tau_{xy}}{\sigma_x - \sigma_y}$

$\Rightarrow 2\theta = \tan^{-1}\left(-\dfrac{2\times 6000}{4000+8000}\right)$

$\Rightarrow 2\theta = \cancel{71.56^\circ}\ 45^\circ$

$\therefore \theta = \cancel{35.78^\circ}\ 22.5^\circ$



Now, For a plane at 30° countar clockwise, we need to go $(2\times30) = 60^\circ$ counterclockwise from AC or x axis.

$\therefore$ From σ-axis, $\cancel{60^\circ - 22.5}$ $\cancel{(60^\circ - 22.5^\circ)} = (60^\circ - 45^\circ) = 15^\circ$ counter clockwise

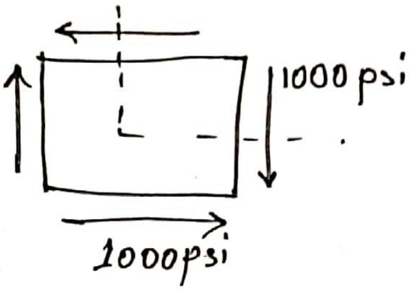
Thus co-ordinates of H are the stress components, 30° from the x face.

$\therefore$ ~~H(σ_x~~ $\sigma_x' = 8485.28 \cos 15^\circ - 2000 = 6196.65 \approx 6200$ psi

$\tau_{xy}' = 8485.28 \sin 15^\circ = 2196.14$ psi

As:

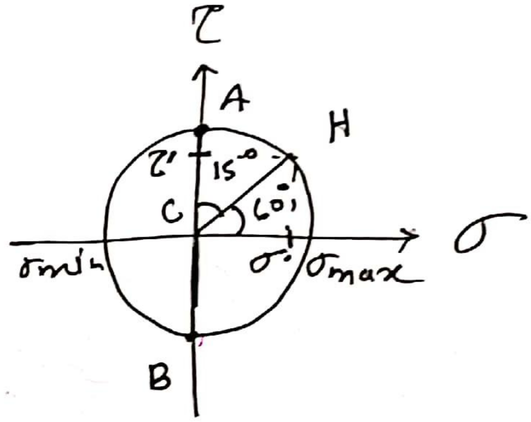
* Determine the principal stresses. Determine the stresses of the faces at 15° clockwise. [2010, 2018]



Solution:

$\sigma_x = 0$ $\quad \tau_{xy} = 1000$

$\sigma_y = 0$ $\quad \tau_{yx} = -1000$



$\therefore C = 0$

$\therefore R = \sqrt{0^2 + (\tau_{xy})^2} = 1000\ psi$

$\therefore \sigma_{max} = 1000 psi$; $\tau_{max} = 1000$

$\sigma_{min} = -1000 psin$; $\tau_{min} = -1000$

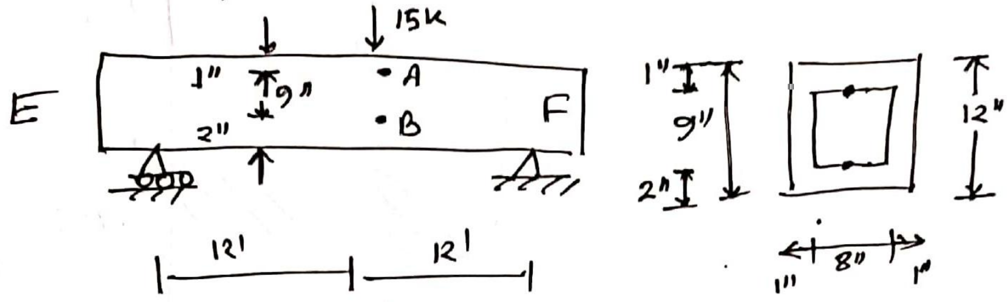
Now, for 15°,

$\sigma' = 1000 \cos 60° = 500 psi$

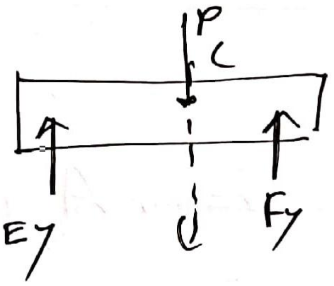
$\tau' = 1000 \sin 60° = 866.03\ psi$

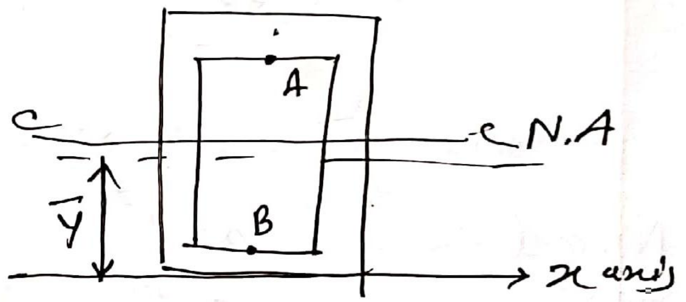
As:

Compute the principal stress and maximum shearing stress of points A and B. [2010; 2017]



solution:





From Chapter 5, to find N.A,

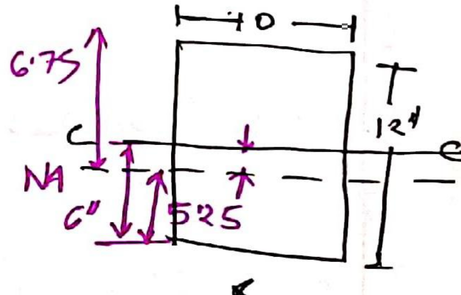
$A\bar{y} = \Sigma Ay$

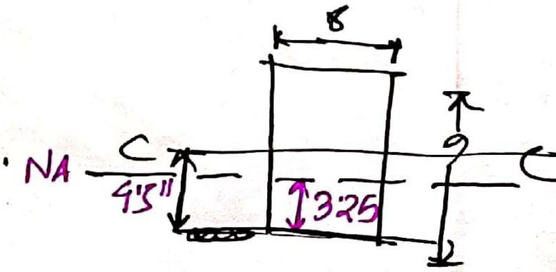
$\Rightarrow (10\times12 - 9\times8)\,\bar{y} = (10\times12)\times\frac{12}{2} - (9\times8)\times\left(2+\frac{9}{2}\right)$

$\therefore \bar{y} = 5.25$ in

$\therefore I_{NA} = \frac{10\times12^3}{12} + (10\times12)(6-5.25)^2 - \left\{\frac{8\times9^3}{12} + (8\times9)\times\left(\frac{9}{2}-3.25\right)^2\right\}$

$= 909$ in^4





$Q_A = A\bar{y} = (10\times1)\times\left(5.75+\frac{1}{2}\right) = 62.5$ inch^5

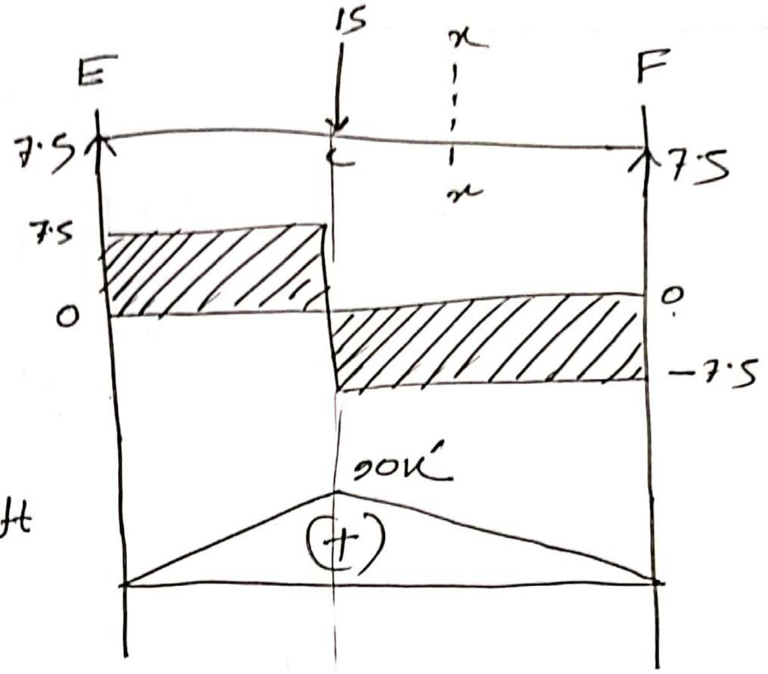
$Q_B = A\bar{y} = (10\times2)\times\left(3.25+\frac{2}{2}\right) = 85$ in^5

$\Sigma F_y = 0$

$\Rightarrow F_y + E_y = 15k$

$\therefore E_y = F_y = 7.5k$

$\therefore V = 15k$



$M_{CF} = 7.5x - 15(x-12)$

$\therefore M_C = 7.5 \times 12 = 90$ kft

$= 90 \times 12 = 1080$ kin

As there's no axial stres on the beam, A point thus, $\sigma_A = 0$

$\boxed{\therefore \text{Normal stresses}}$

$\sigma_f = \frac{Mc}{I} = \frac{1080 \times 5.75}{909}$

$\therefore \sigma = 6.832$ ksi

$\boxed{\text{Shear stress}}$ at A,

$\tau_A = \frac{VQ_A}{Ib} = \frac{15 \times 62.5}{909 \times 10} = 0.103$ ksi

$\boxed{\text{Principal stresses}}$ at A,

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

$= \frac{6.83 + 0}{2} \pm \sqrt{\frac{6.83}{2}^2 + 0.103^2}$

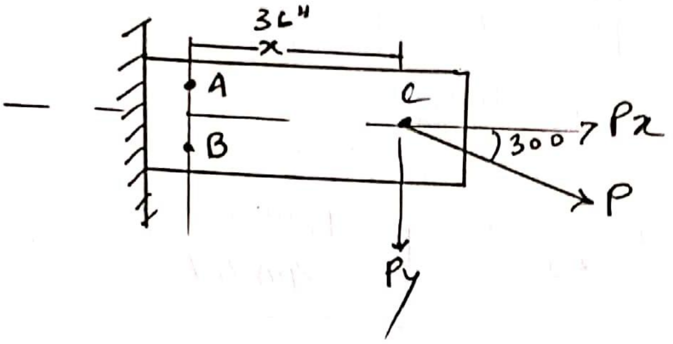
$= 3.416 \pm 3.418$

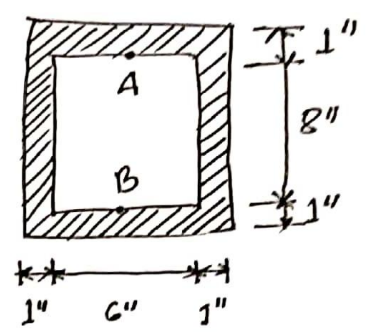
$\therefore \sigma_{max} = 6.834$ ksi
$\sigma_{min} = 0$ ksi } Ans

$\boxed{\text{Max shearing stress,}}$

$\tau = \pm\sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^2} = \pm 3.418$ ksi Ans

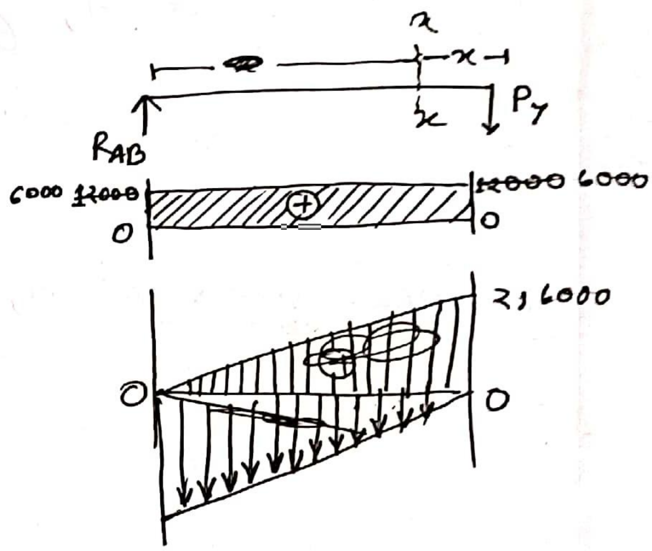
* Compute the principal stresses and maximum shearing stress at point A and B in figure below at the section $x = 36''$ due to $P = 12000\,lb$





Solution: $P_x = 12000 \times \cos 30^\circ = 10392.30\ lb$

$P_y = 12000 \times \sin 30^\circ = 6000\ lb$



$V = 12000\ lb \times \sin 30 = 6000\ lb$

$M = \cancel{12000 \times x} - 6000x$

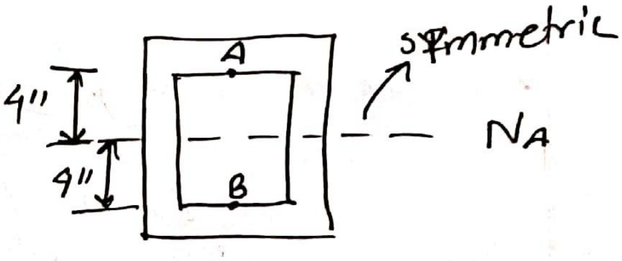
$\therefore M_{AB} = 6000 \times 36 = 216000\ lb\ in$

$M_C = \cancel{6000 \times 36 = 216000\ lb\text{-}in}\ 0.$

Location of NA:

$$\bar{y}\left(10'' \times 8'' - 6'' \times 8''\right) = (10 \times 8) \times 5 - (8 \times 6)(1 + 4)$$

$\therefore \bar{y} = 5''$



$$\therefore I_{NA} = \frac{8 \times 10^3}{12} - \frac{6 \times 8^3}{12}$$

$$= 410.667\ in^4$$

$Q_A = (8 \times 1) \times (4 + 0.5) = 36\ in^3$

$Q_B = (8 \times 1) \times (4 + 0.5) = 36\ in^3$

$A = (10 \times 8) - (8 \times 6) = 32\ in^2$

For Point A:

Axial ~~stress~~ force $P_A = 10392.30$ lb
shear force, $V = 6000$ lb
moment, $M = 216000$

* Normal stresses at A,

$$\sigma = \frac{P_x}{A} + \sigma_f$$

$$= \frac{P_x}{A} + \frac{Mc}{I}$$

$$= \frac{10392.30}{32} + \frac{216000 \times 4}{410.67}$$

$$= 2428.638402$$

* Shear stress at A, $\tau = \frac{VQ_A}{Ib} = \frac{6000 \times 32}{410.667 \times 8}$

$= 58.441$ psi

* Principal stress at A, $\sigma = \frac{\sigma_x + \sigma_y}{2} \pm \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + (\tau_{xy})^2}$

$$= \frac{2428.63 + 0}{2} \pm \sqrt{\left(\frac{24.2863 - 0}{2}\right)^2 + 58.44^2}$$

$\sigma_{max} = 2430.035$ psi

$\sigma_{min} = -1.405$ psi

* Maximum shearing stress, A

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

$$= \pm \sqrt{\left(\frac{2428.638}{2}\right)^2 + 58.44^2}$$

$= \pm 1215.72$ psi

For Point B:

* Normal stress at B, $\sigma_B = \sigma_a * \sigma_f$ → compression at B

$$= \frac{P_x}{A} - \frac{Mc}{I}$$

$$= \frac{10372.30}{32} * \frac{216000 \times 4}{410.67} = -1779.11$$

* Shear stress at B, $\tau_B = \frac{VQ_B}{Ib} = \frac{6000 \times 32}{410.667 \times 8} = 58.441$

* Principal stress at B,

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

$$= \frac{-1779.11 + 0}{2} \pm \sqrt{\left(\frac{-1779.11}{2}\right)^2 + 58.44^2}$$

$\sigma_{max} = 1.767$ psi (T)

$\sigma_{min} = -1781.178$ psi (C)

* Maximum shearing stress,

$$\tau = \pm \sqrt{\left(\frac{-1779.11 - 0}{2}\right)^2 + 58.44^2}$$

$= \pm 89.47$ psi