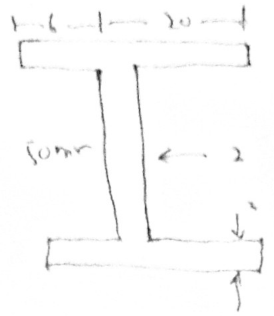
Q1

Part A



Required location of shear center

Sol As we know that

$$e = \frac{t_f\, h^2 b^2}{4I}$$

$$I = 2\left(\frac{bh^3}{12} + Ay^2\right) + \left(\frac{bh^3}{12} + Ay^2\right]$$

$$= 2\left[\frac{26(2)^3}{12} + (26 \times 2)(25)^2\right] + \left[\frac{2(50)^3}{12} + 0\right]$$

$I = 50034.66 + 20833$

$I = 70867.99\ mm^4$

$$e = \frac{2(50)^2(21)^2}{4(70867.99)} = 11.02\ mm$$

So shear center $e = \boxed{11.02\ mm}$

Q1

Part B

Given Data

$H = 26 ft$

Assume diameter $= D = 22 ft$

Tangential stress $= 600\ lb/ft^2$

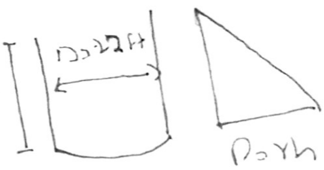
=> specific weight of water tank $= 62.4\ lb/ft^3$

we have to find the thickness =?

Sol

Pressure developed by water $P = \gamma h$

$$\sigma_t = \frac{PD}{2t}$$



$$\sigma_t = \frac{PD}{2t} = \frac{\gamma h D}{2t}$$

$$2t = \sigma_t = \gamma h D$$

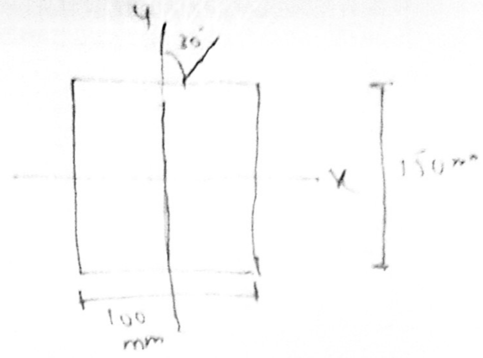
$$2t = \frac{\gamma h D}{\sigma_t}$$

$$t = \frac{\gamma h D}{\sigma_t \times 2}$$

$$t = \frac{\left(\frac{62.4}{(12)^3}\right) \times (26 \times 12) \times (22 \times 12)}{6000 \times 2}$$

$$\boxed{t = 0.24''}$$

Q2



Moment of inertia

$$I_z = \frac{bh^3}{12} = \frac{0.1(0.15)^3}{12}$$

$$I_z = 2.8125 \times 10^{-5}$$

Now

$$I_y = \frac{hb^3}{12} = \frac{0.15(0.1)^3}{12}$$

$$I_y = 1.25 \times 10^{-5}$$

$$\sigma = \frac{M_z y}{I_z} + \frac{M_y z}{I_y}$$

$$\sigma = \frac{M\cos\theta}{I_z} + \frac{M\sin\theta}{I_y}$$

$$M = \cos\theta = P\cos\theta = M_z$$
$$= 12\cos 30^\circ = M_z$$

$$M_z = 10.8510$$

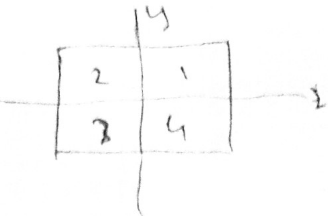
$$M\sin\theta = P\sin\theta = M_y$$

$$M_y = -11.8563$$

$$\sigma = \left(\frac{M_z}{I_z}\right) + \left(\frac{M_y}{I_y}\right)$$

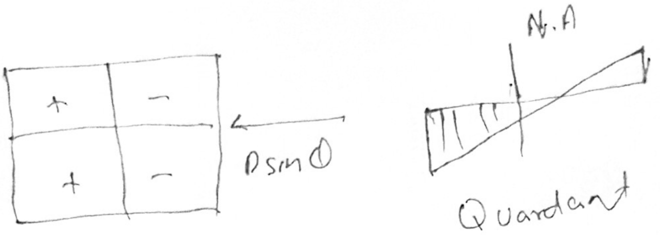
$$\sigma = \frac{1.851}{2.812 \times 10^{-5}} + \left(\frac{-11.8563}{1.25 \times 10^{-5}}\right) - 882678\ Nm^2$$

Sign Convention



If we take compression as negative and tension as positive and the beam is simply supported

Quardand 1, 2 -ve
Quardant 3 4 +ive



Quardant 1,4 -ve
2 3 +ive

In case of unsymetrical loading of an angle of 'α' The principle axis the netural axis and the algebric sum of stress of N.A is zero

$$\sigma = \frac{M\cos\theta}{I_z} y + \frac{M\sin\theta}{I_y} - z \quad \text{——} \; (1)$$

in this case N.A passes through 2,4

$$\sigma = \frac{M\cos\theta\, y}{I_z} + \frac{M\sin\theta}{I_y} z$$

Let consider a point A on N.A lies in quadrand 2 where -
Bending stress due to $P\cos\theta$ is compressive
and bending stress due to $P\sin\theta$ is Tensile.

$eq^n (1) \Rightarrow \quad 0 = \frac{M \cos\theta \, y_A}{I_z} + \frac{M \sin\theta}{I_y}$

$= \frac{-M\cos\theta \, y_A}{I_z} + \frac{M\sin\theta}{I_y} z_A$

$\frac{y_A}{z_A} = \frac{I_z}{I_y} \frac{\sin\theta}{\cos\theta} \Rightarrow \tan\alpha = \frac{I_z}{I_y} \tan\theta$

Now put value of I_z I_y and θ in eq (11)

$\tan\alpha = \frac{I_z}{I_y} \tan 30$

$\Rightarrow \tan\alpha = \frac{-8.125 \times 10^{-5}}{1.25 \times 10^{-5}} (\tan 30^\circ)$

$\tan\alpha = -14.4124$

$\alpha = \tan^{-1}(-14.4124)$

$\alpha = 1.5^\circ$

$\alpha = 1^\circ 30' 5''$

Q2
Part B

Given data

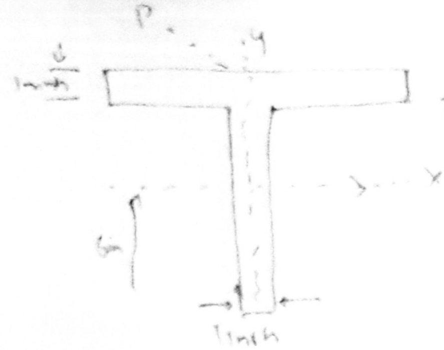
$L = 10\ ft$

$I_x = 112.6\ in^4$

$I_y = 18.7\ in^4$

$\sigma_c = 12000\ psi$

$\sigma_t = 5000\ psi$



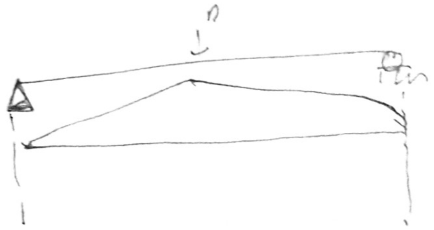
(a)

By looking to the figure, we can judge that maxim compression would occur on A and maximum tension at C. at B there will be tension as well as compression which will reduce the effect of each other so we will calculate stresses at A & C

So $\sigma_A = \dfrac{M_x y}{I_x} + \dfrac{M_y x}{I_y}$ (comp)

$\sigma_C = \dfrac{M_x y}{I_x} + \dfrac{M_y x}{I_y}$ Tension

Now M_x & M_y



So $M_x = \dfrac{P \cos 60 \times (16 \times 12)}{4}$

$\cancel{M_y = 0}$

$M_x = 48P \cos 60$

$M_y = \dfrac{P \sin 60\ (16 \times 12)}{4}$

$M_y = 48 P \sin 60$

Now $\sigma_A = \dfrac{M_x y}{I_x} + \dfrac{M_y x}{I_y}$

$12000 = \dfrac{48P \cos 60^\circ \times 3.07}{112.6} + \dfrac{48 P \sin 60^\circ \times 3}{18.7}$

Solving The equation

$$\boxed{P = 1638.6\ lb}$$

Now

$$\sigma_c = \frac{M_x y}{I_x} + \frac{M_y x}{I_y}$$

$$5000 = \frac{48P\cos 60 \times (5.93)}{112.6} + \frac{48P\sin 60 \times 0.5}{18.7}$$

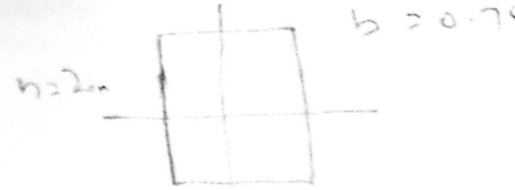
Solving the equation

$$P = 2104.9\ lb$$

So The maximum load P applied should be

1638.6 lb

Q3



Length of strutl

Strut is a compression member act as a coloumn

Case 1

Strutt act as a hinged coloumn about an axis perpendicular to the 2in dimension

$$I = I_x = \frac{(0.75)(2)^3}{12}$$

$$= 0.5\,in$$

$L_e = L$ (for Hinged ended coloumn)

$$P_{cr} = \frac{n^2 EI \pi^2}{Le^2} =$$

$$= \frac{(1)^2 (10.3\times10^6)(0.5)(\pi^2)}{(6\times12)^2}$$

$P_{cr} = 9804.8\,L$

$$P_{safe} = \frac{P_{cr}}{\text{factor of safty}}$$

$$= \frac{9804.8\,lb}{2}$$

$P_{safe} = 4902.4\,lb$

Case 2

Strut or column act as a fixed ended column about an axis parallel to 2 in dimention

$$I = I_y = \frac{2(0.75)^3}{12} =$$

$$= 0.07 \text{ in}^4$$

$L_e = \frac{L}{2}$ for fixed Ended column)

Then

$$P_{cr} = \frac{(n^2)\, E I \pi^2}{L_e^2}$$

$$\frac{(1)^2(10.3\times10^6)(0.07)(\pi^2)}{\left(\frac{6\times12}{2}\right)^2}$$

$P_{cr} =$ 5490.7 lb

$$P_{safe} = \frac{P_{cr}}{\text{factor of safty}}$$

$$= \frac{5490.7}{2}$$

$P_{safe} = \boxed{2745.35}$

In both cases take the smaller value of P.safe

$P_{safe} = 2745.35 <$ 4902.4