PAPER:

MECHANICS OF SOLIDS 2

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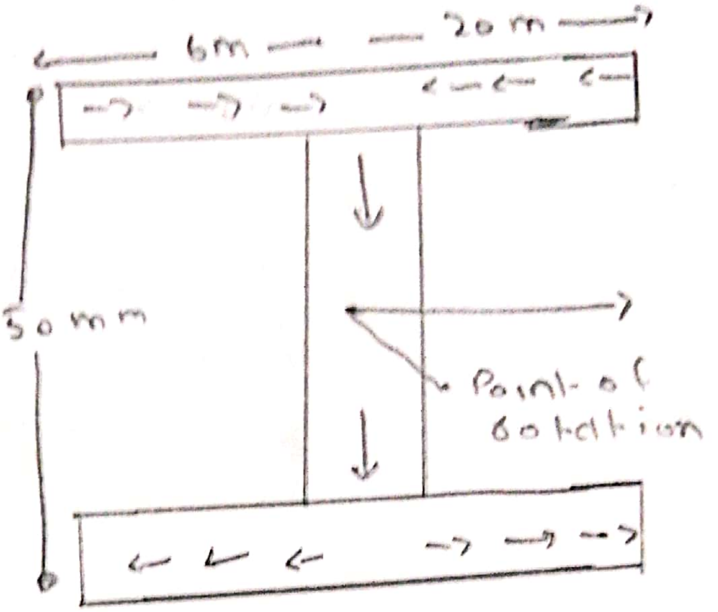
Q No 1 :



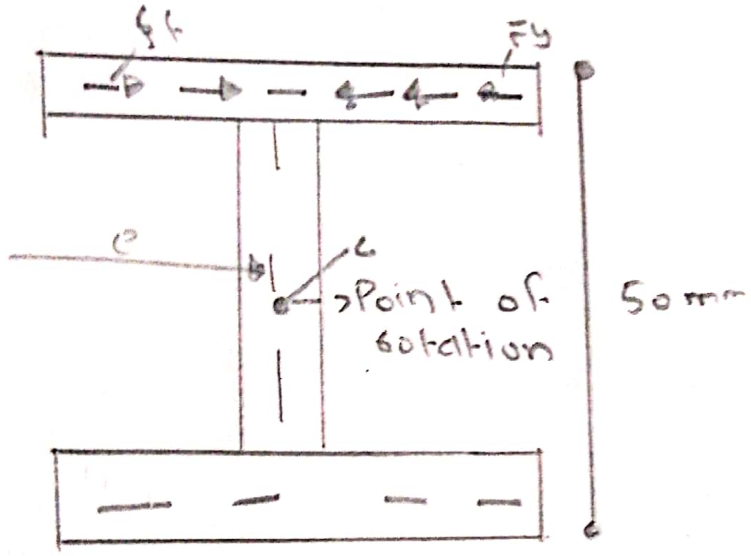
The section is symetrical about x-axis and not at y axis.

So any external force on section will create twisting in the section.

So in order to avoid twisting we will find out the plane where external load will balance the internal shear flow in the section.

As the section is symetrical about x-axis.

So the shear centre must lies the same as where the x-axis lines.



$\Sigma M_c = 0$

clock wise moment = Anti clock wise moment

$V \times e + f_f \times 50 = f_f$

$I = \Sigma[\bar{I} + A d^2)$

$$e = \frac{F_f \times 50 - f_f \times 50}{V}$$

Find I_x an y.

$$I = 2\left[\frac{26 \times (2)^3}{12} + (26 \times 2) \times (25-1)^2\right] + \left[\frac{2 \times (50)^3}{12} + 0\right]$$

$I_{xx} = 59938.66 + 20833.34$

$I = 80771.99 \, mm^4$

$4y = 25 \, mm$

Now for flange.

$$F_f = \int_0^x q_f \, dx$$

$$= \int_0^x \frac{VQ}{I} \, dx$$

$$= \int_0^x \frac{V}{80771.9} \, dx$$

$$= \frac{25V}{40386} \int_0^x x \cdot dx$$

$$\boxed{\begin{aligned} Q &= A\bar{y} \\ Q &= 50x \end{aligned}}$$

$$F_f = \frac{25V}{40386} \left| \frac{x^2}{2} \right|^x$$

Now for $y = 20$

$$F_f = \frac{25V}{40386}\left(\frac{(20)^2}{2} - 0\right)$$

$$F_f = 0.123V$$

left side

$x = 6$

$$F_f = \frac{25V}{40386}\left[\frac{(x)^2}{2}\right]_0^6$$

$$F_f = \frac{25V}{40386}\left[\frac{(6)^2}{2}\right]_0^6$$

Now Putting values

$$e = \frac{-0.011V + 50 + 0.123 \times 50}{V}$$

$e = 5.6$ mm.

RESULT:

$e = 5.6$ mm

QNO1 PART B (CLO2)

GIVEN:

Circumferential stress: $\sigma_c \leq 6000 Psi$

$\gamma = 62.4 \, lb/ft^3$

$D = 22 ft$

Height $= H = 26 ft.$

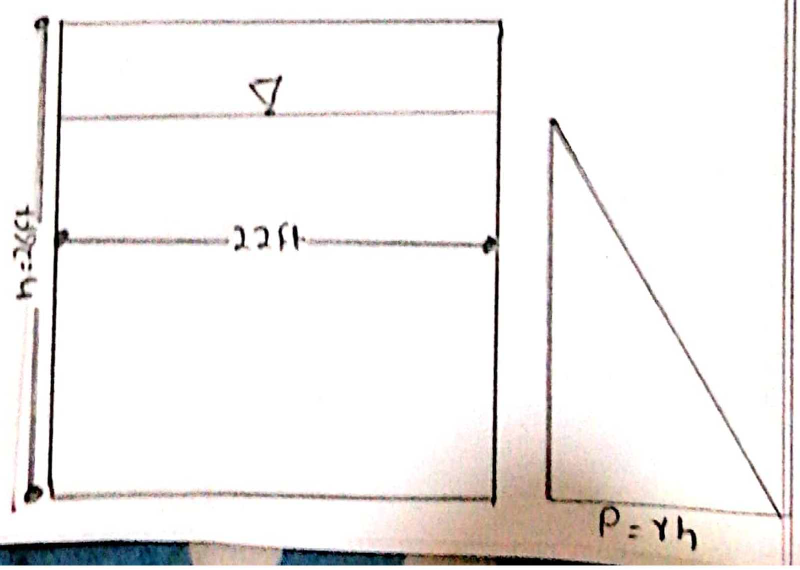
TO FIND:

The thickness of the wall under the water tank = ?

SOLUTION:

As we know that

$P = \gamma h$



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

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

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

Putting values.

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

$t = 0.02$ ft or 0.240 inch

RESULT:

$t = 0.02$ ft or 0.240 inch.

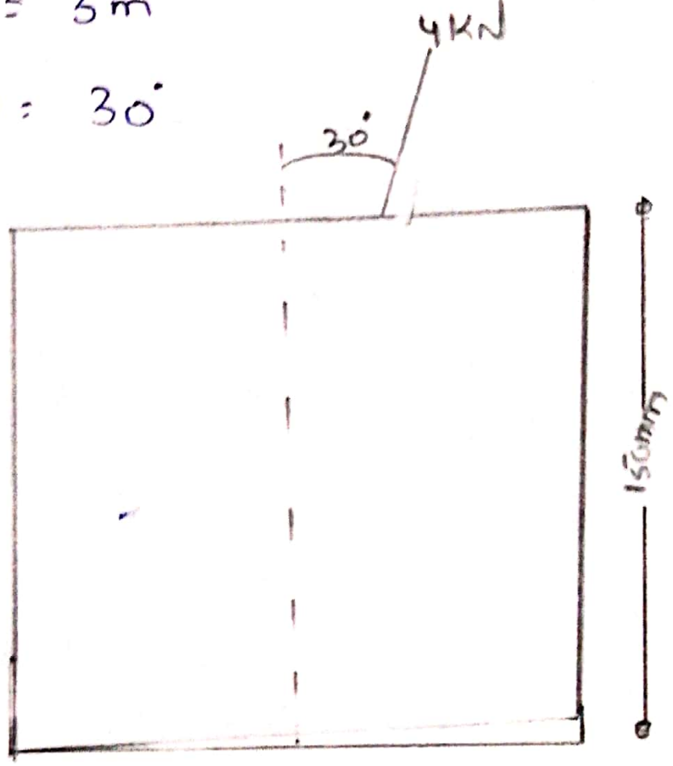
QNO2 PART a (CLO3)

GIVEN:

$W = 4\ KN$

$l = 3m$

$\theta = 30°$

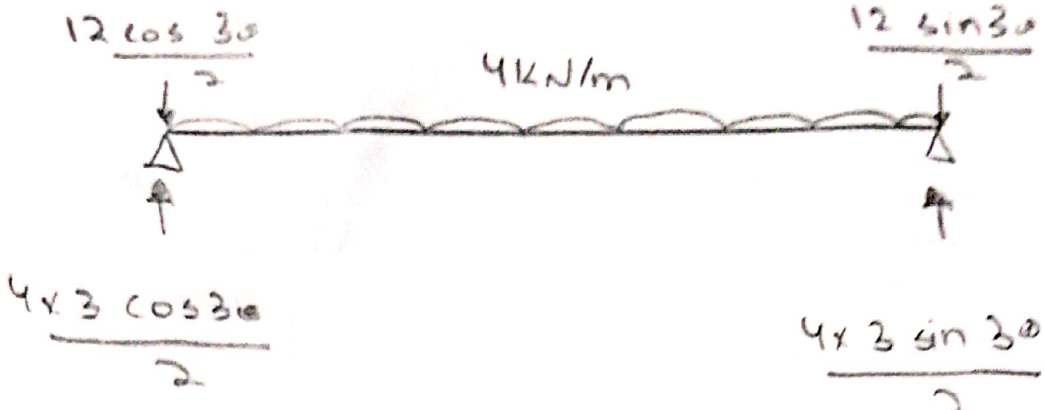


TO FIND:

a, Max bending stresses at mid spain :?

ba, locate neutral axis = ?

SOLUTION:



For UDL max moment max at mid section.

$$M_z = \frac{wL}{2} \times \frac{L}{4}$$

$$M_z = \frac{wL^2}{8}$$

$$M_z = \frac{4\cos 30 \times 3^2}{2}$$

$$M_z = 3.9\ KN/m$$

$$M_z = 3.9\ KN/m$$

For M_y

$$M_y = \frac{4\sin 30 \times 3^2}{8}$$

$$M_y = 2.25\ KN.m$$

$$M_y = 2.25\ KN.m$$

$$I_y = \frac{0.150 \times 0.1^3}{12}$$

$$I_y = 1.2 \times 10^{-5} \, m^4$$

$$I_z = \frac{0.100 \times (0.150)^3}{12}$$

$$I_z = 2.81 \times 10^{-5} \, m^4$$

To bending stress at mid span.

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

$y = 0.075 \, m$

$z = 0.05 \, m$

$I_z = 2.81 \times 10^{-5} \, m^4$

$I_y = 1.25 \times 10^{-5} \, m^4$

$$\sigma_z = \frac{M_z y}{I_z}$$

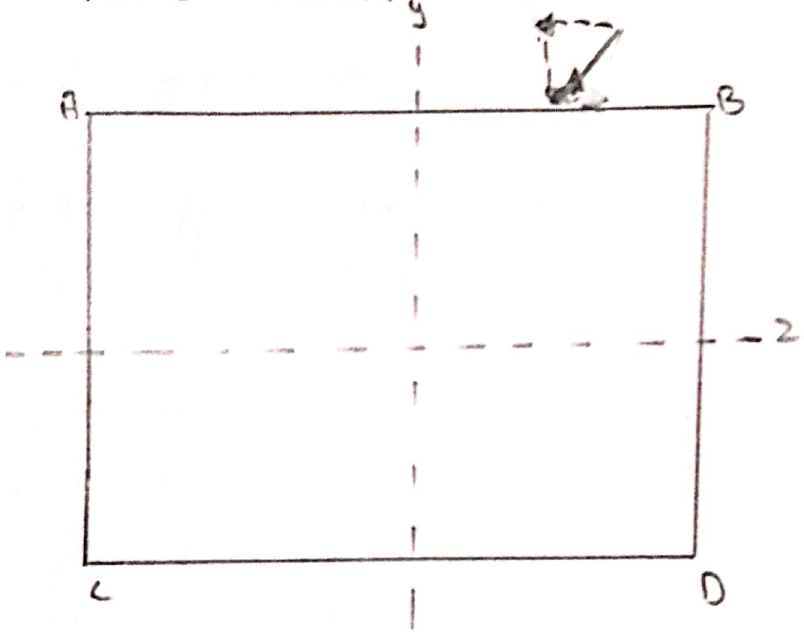
$$\sigma_z = \frac{3.9 \times 0.75}{2.81 \times 10^{-5}}$$

$$\sigma_z = 10409.25 \, kN/m^2$$

$$\sigma_y = \frac{M_y}{I_y} z$$

$$\sigma_y = \frac{2.25 \times 0.05}{1.25 \times 10^{-5}}$$

$\sigma_y = 9000$ kN/m



Maximum bending stress at extreme fiber.

$\sigma_A = -\sigma_z + +\sigma_y$

$\sigma_B = -\sigma_z + -\sigma_y$

$\sigma_C = +\sigma_z + +\sigma_y$

$\sigma_D = -\sigma_z + -\sigma_y$

$\sigma_z = 10409.25$ kN/m^2

$\sigma_y = 9000$ kN/m^2

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So we conclude.

$\sigma_A = -10409.25 + 9000 = (-1409.25 \, kN/m^2)$

$\sigma_B = -10409.25 + (-9000) = (-1940.25 \, '')$

$\sigma_C = 10409.25 + 9000 = (1940.25 \, kN/m^2)$

$\sigma_D = 10409.25 + (-9000) = (1409.25 \, kN/m^2)$

Q no 2 Part b (CLO3):

GIVEN:

$\bar{y} = 3.07 \text{ in}$

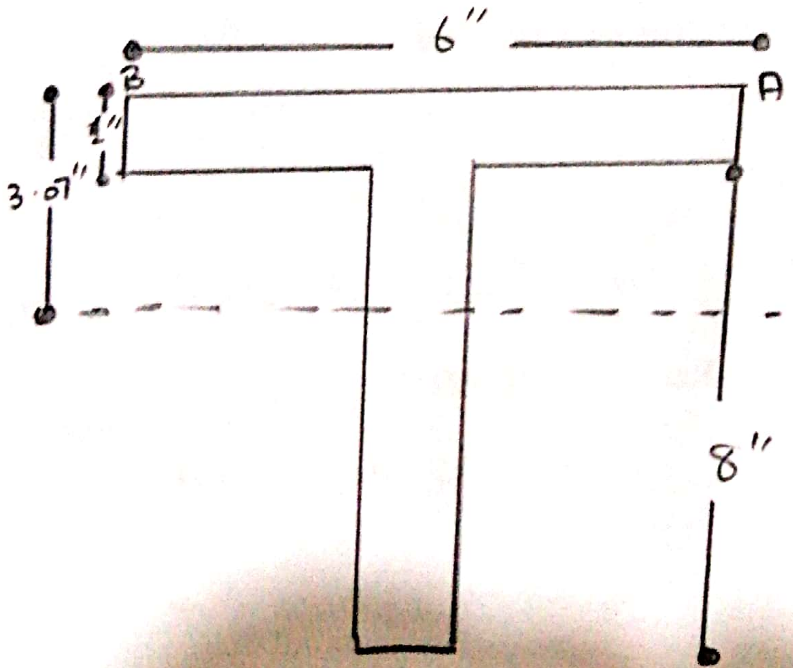
$x = 3 \text{ in}$

$I_x = 112.6 \text{ in}^4$

$I_y = 18.7 \text{ in}^4$

Tensile stress $\leq$ 5000 Psi

Compressive stress $\leq$ 12000 Psi



To FIND:

Max load that will not overstress the beam ?

SOLUTION:

The maximum bending stresses occur at the mid section due to maximum bending moment. So that the critical section is the mid section where the compressive and tensile stresses can exceed the limiting values.

"We also know that at any given section the maximum stresses occur at the extreme fibe. For exmaple at Point A,B,C,D.

We know that for Point load at mid section is

$$M = \frac{PL}{4}$$

$$M_x = \frac{P\cos 60 \times 16 \times 12}{4}$$

$$M_x = 24P$$

$$M_y = \frac{P \sin 60 \times (16\times12)}{4}$$

$$M_y = 41.57\ P$$

Stresses at Point A, B, C, D.

POINT A:

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

$$\sigma_z = \frac{24 \times 3.07}{112.6} + \frac{41.57 \times 3}{18.7}$$

$$\sigma_z = -0.654 + 6.667$$

$$\sigma_z = 6.014 \text{ (Tension)}$$

Tension $\leq$ 5000 Psi

$$P = \frac{5000}{6.014}$$

$$P = 831.94 \text{ lb.}$$

For Point B.

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

$$\sigma_B = -0.654 + (-6.667)$$

$$\sigma_B = -7.231$$

$\sigma_B = -7.231$ (compression)

Compression ≤ 12000 Psi

$$P = \frac{12000}{7.231}$$

$$P = 1659.52 .\cancel{lb}$$

Controlling value b/w A and B is equal = 831.94 lb.

POINT C:

$$\sigma_c = 0.654 + 6.667$$

$$\sigma_c = 7.321$$

$\sigma_c = 7.321$ (Tension)

Tension $\leq$ 5000 Psi

$$P = \frac{5000}{7.321}$$

$P = 682.97$ lb.

$P = 682.97$ lb.

POINT D:

$\sigma_D = 0.654 + (-6.667)$

$\sigma_D = -6.013$

$\sigma_D = -6.013$ compression.

Compression $\leq$ 12000

$$P = \frac{12000}{6.013}$$

$P = 1995.67$ lb.

Controlling value b/w C and D is equal to = 682.97 lb.

Controlling Points:

B/w A B = 831.94 lb.

B/w C D = 682.97 lb.

QNo 3:

GIVEN:

$L = 10$ ft

$E = 10.3 \times 10^6$ psi

$n = 2$

TO FIND:

Factor of safety = 2.

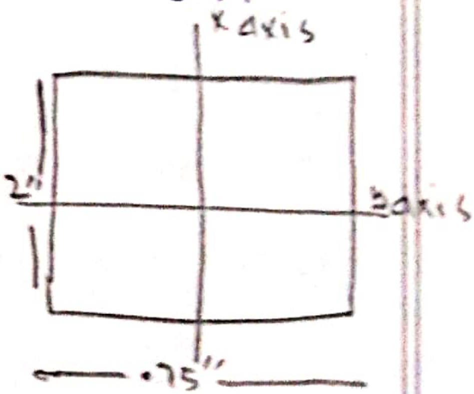
$P_{safe} = ?$

CASE 1:

Strut act as a hinge coloumn about an axis perpendicular to the 2 in dimension.

$$I_x = \frac{b\,h^3}{12}$$

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



$$I_x = 0.5$$

As we know that

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

$$P_{cb} = \frac{(2)^2 \times (10.3 \times 10^6) \times (0.5)(3.14)^2}{(10 \times 12)^2}$$

$P_{cb} = 14104.70$ lb

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$$P_{safe} = \frac{P_{cb}}{FOS}$$

$P_{safe} = 7052.35$

$P_{safe} = 7052.35$

CASE 2:

Strut coloumn act as fixed end coloumn about an Parrallel to 2in side.

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

$I_y = 0.0703 \text{ in}^4$

$l_e = \frac{L}{2}$ (For Fixed ended coloumn)

P_c

$$P_{cb} = \frac{n^2 E I \pi^2}{L_e^2}$$

$P_{cb} = (2)^2 \times (10.3\times10^6) \times (0.00703)(3.14)^2$

$P_{cb} = 7932.48$

$P_{cr} = 7932.48$

$$P_{safe} = \frac{P_{cb}}{FOS}$$

$$P_{safe} = \frac{7932.48}{2}$$

$P_{safe} = 3966.24$ lb.

In both cases we will take smallest value of P_{safe}.

$P_{safe} = 3966.24 < 7052.35$

$P_{safe} = 3966.24$ lb.