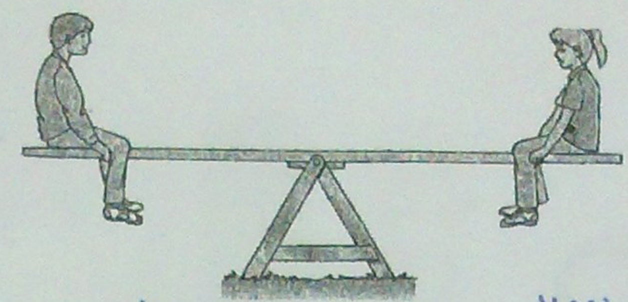
P1. [25]

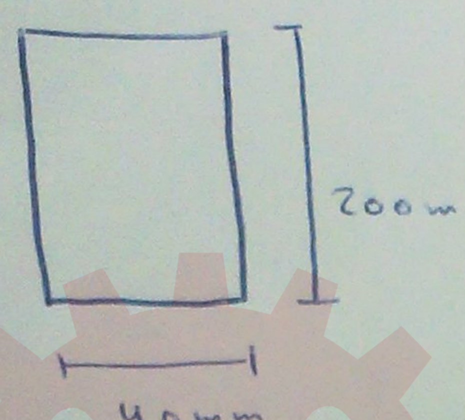
A seesaw weighing 45 N/m of length is occupied by two children. Each child weighs W = 400 N. The gravity center of each child is a = 2.5 m from the fulcrum. The board is of length L = 6 m, having a rectangular cross section of h = 40 mm and b = 200 mm.

1. Draw the v-x and m-x diagrams.
2. Calculate $\sigma_{max,}$ and τ_{max} in the board.



$\Sigma F_y = 0 \Rightarrow -400 + R - (45 \times 6) - 400 = 0$

$R = 800 + 270 = \boxed{1070\ N}$



$I = I + Ad^2$

$= \frac{bh^3}{12} + Ad^2$

$= \frac{0.2(0.04)^3}{12} + (0.04 \times 0.2 \times (0.1)^2)$

$= 8.1 \times 10^{-5}$

$\sigma_{max} = -\frac{My}{I}$

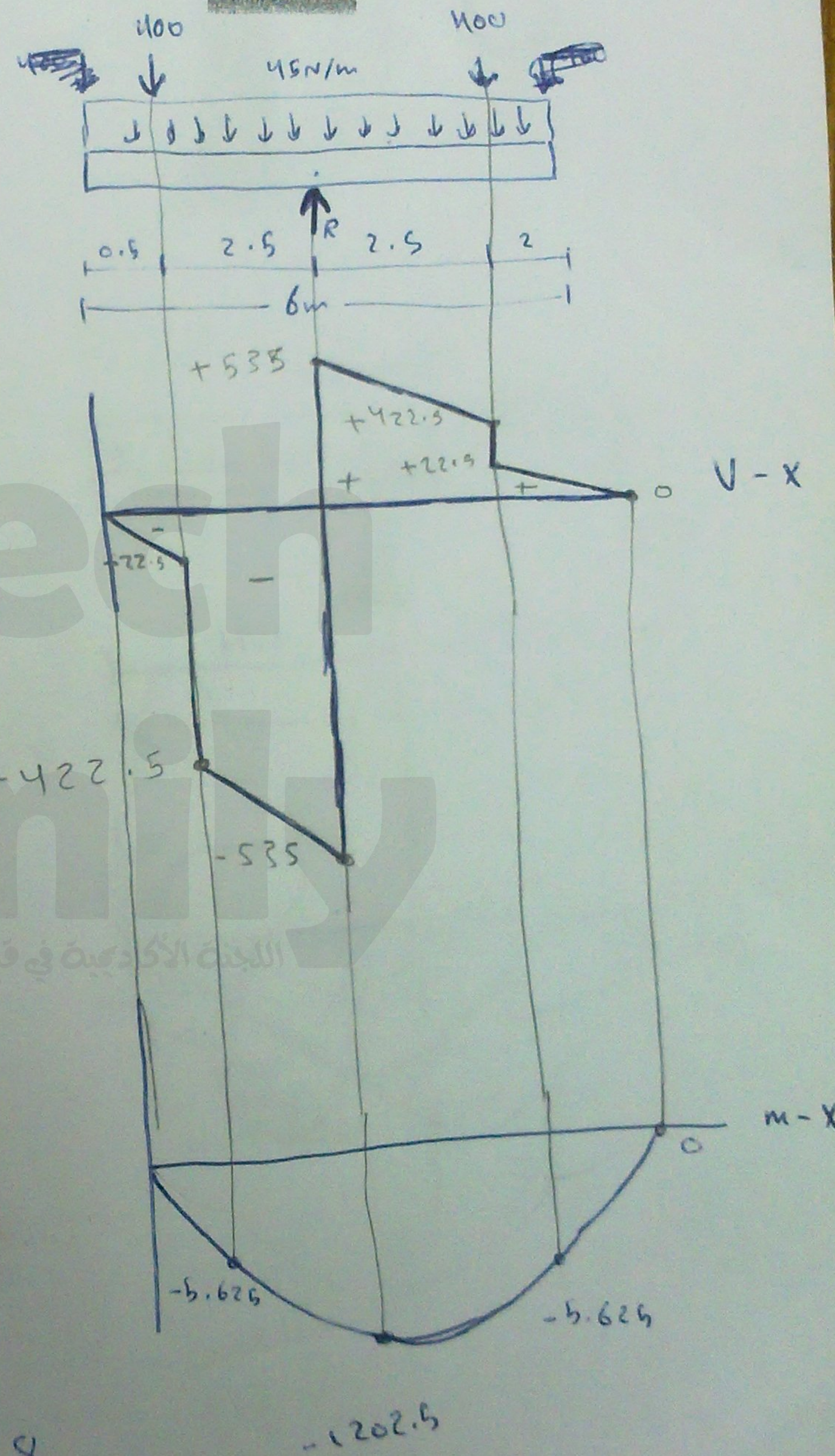
$= -\frac{(-1202.5)(0.1)}{8.1 \times 10^{-5}}$

$\sigma_{max} = 1.5 \times 10^{-4}$

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

$Q = yA = 0.1 \times 0.04 \times 0.2 = 8 \times 10^{-4}$

$\tau = \frac{535 \times 8 \times 10^{-4}}{8.1 \times 10^{-5} \times 0.04} = 132098.8$

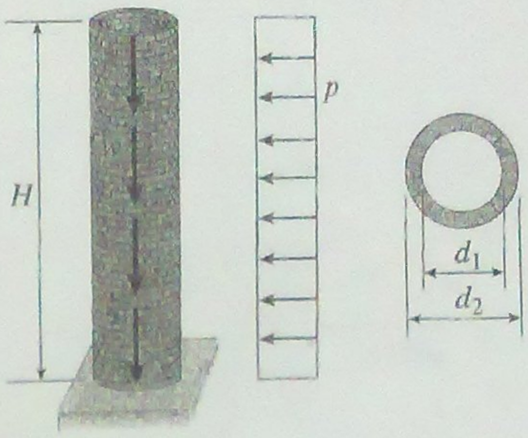


P2. [25]

A cylindrical brick chimney of height H weighs $q = 12$ kN/m of height. The inner and outer diameter are $d_1 = 0.9$ m and $d_2 = 1.2$ m, respectively. The wind pressure against the side of the chimney is $p = 480$ N/m^2 of the projected area, see figure.

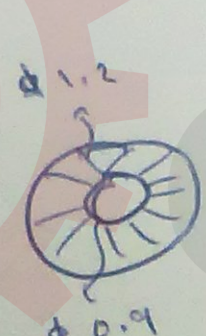
Determine the maximum height H of the chimney if there is to be no tension in the brick work.

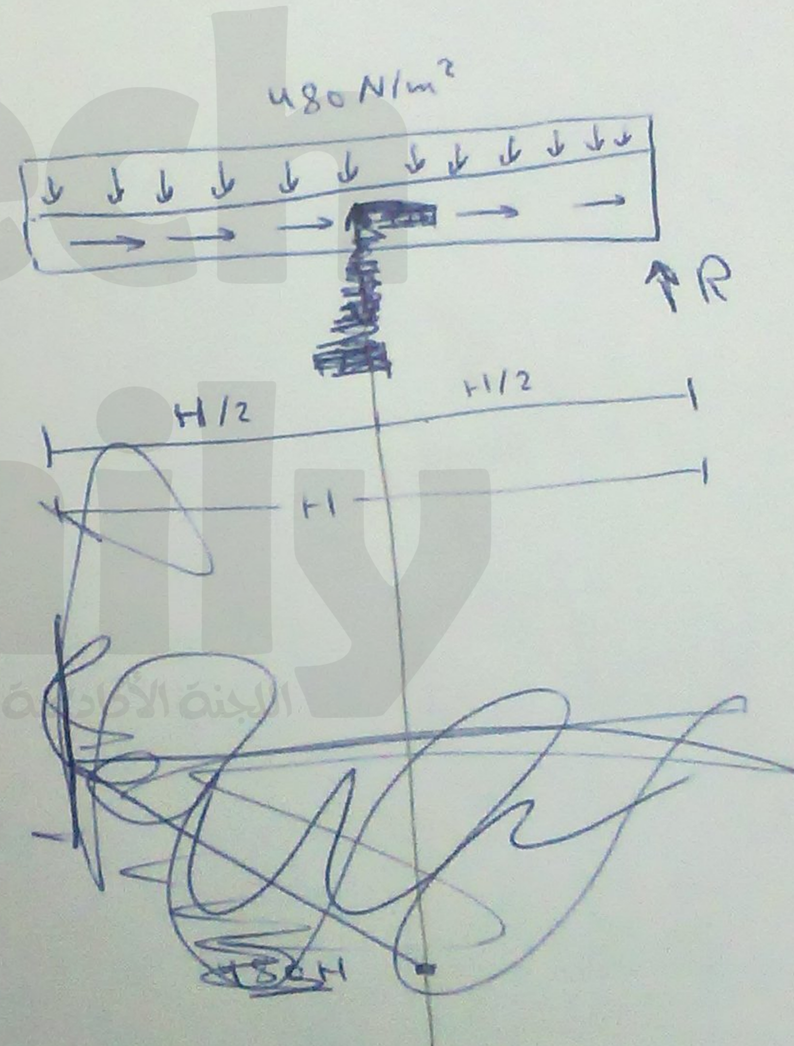
$$P = \frac{F}{A}$$



$$F = 480 * \frac{\pi}{4}(1.2 - 0.9)^2$$

$$F = 33.9 \text{ N}$$





$$\Sigma M_R = 0$$

$$-480H \times H/2 + 12(0.15) = 0$$

$$+240H^2 = +12(0.15)$$

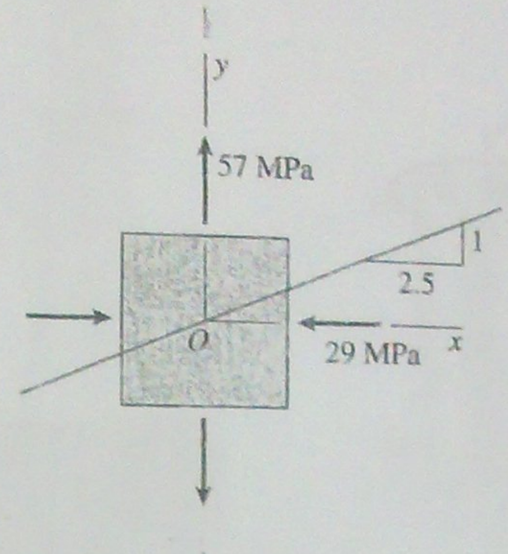
$$H^2 = \frac{12(0.15)}{240}$$

$$H = 0.0866$$

P3. [25]

An element in biaxial stress state is subjected to stresses $\sigma_x = -29$ MPa and $\sigma_y = 57$ MPa, as shown in figure. Using Mohr's circle, determine:

1. The stresses acting on an element oriented at a slope of 1 on 2.5. Show the results on a sketch of properly oriented element.
2. The maximum shear stresses and associated normal stresses. Show the results on a sketch of properly oriented element.



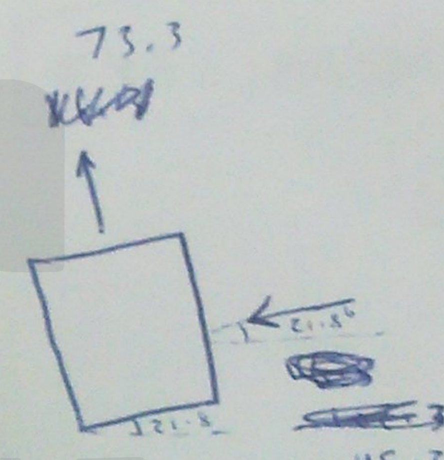
$$C = \frac{\sigma_x + \sigma_y}{2} = 14$$

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

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

$$\tan \theta_p = \frac{1}{2.5} \Rightarrow \theta_p = \tan^{-1}\left(\frac{1}{2.5}\right) = 21.8^\circ$$

$$\tau_{xy} = \frac{(\sigma_x - \sigma_y)(\tan 2(21.8))}{2}$$



$$\boxed{\tau_{xy} = -40.9}$$

$$R = \sqrt{1849 + 1672.81} = 59.3$$

$$\boxed{\tau_{max} = R = 59.3}$$

$$\sigma_1 = C + R = \boxed{73.3}$$

$$\sigma_2 = C - R = \boxed{-45.3}$$

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

$$\tan 2\theta_s = -1.05$$

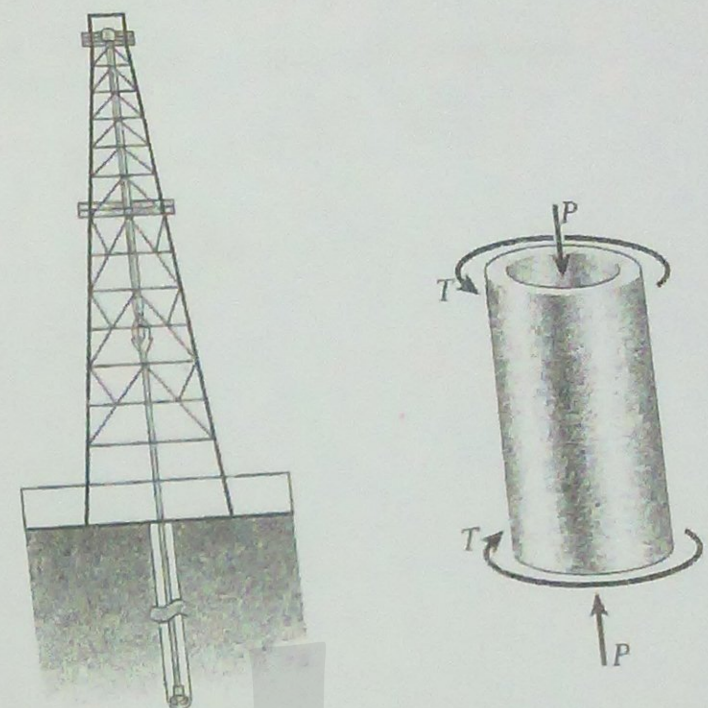
$$\theta_s = -23.2$$

P4. [25]

15 The hollow drill pipe for an oil well has an outer diameter d_o = 150 mm and a thickness t = 15 mm, see figure. Just above the bit, the compressive force P = 265 kN due the weight of the pipe and the torque T = 19 kN.m due to drilling. Determine:

1. the principal stresses, and
2. the maximum shear stresses

in the pipe.



1) Axial stress $\Rightarrow \sigma = \frac{P}{A}$

$$\sigma = \frac{265}{\frac{\pi}{4}(0.15)^2}$$

$$\sigma = 14996 \ Kn/m^2$$

Torsion shear force:

$$\tau = \frac{Tc}{j}$$

$$c = 150\,mm - 15\,mm = 0.135\ m$$

$$j = \frac{\pi}{32}(D^4 - d^4) = \frac{\pi}{32}(0.15^4 - 0.015^4) = 4.9 \times 10^{-5}\ m^4$$

$$\tau = \frac{19 \times 0.135}{4.9 \times 10^{-5}} = \boxed{52346.9}$$

Principal stress $\Rightarrow$ $c = \frac{\sigma_x + \sigma_y}{2} = \frac{14996}{2} = \boxed{7498}$

$$R = \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + (\tau_{xy})^2} = \boxed{52881.2}$$

$$\boxed{\sigma_1 = c + R = 60379.2\ Kn/m^2}$$

$$\boxed{\sigma_2 = c - R = -45383.2\ Kn/m^2}$$

2) maximum shear stress

$$\tau_{max} = R$$

$$\boxed{\tau_{max} = 52881.2}$$