Experiment 1

Center of Pressure on Partially and Fully Submerged Plates

Objective:

- To determine the center of pressure on a partially submerged and fully submerged plane surface.

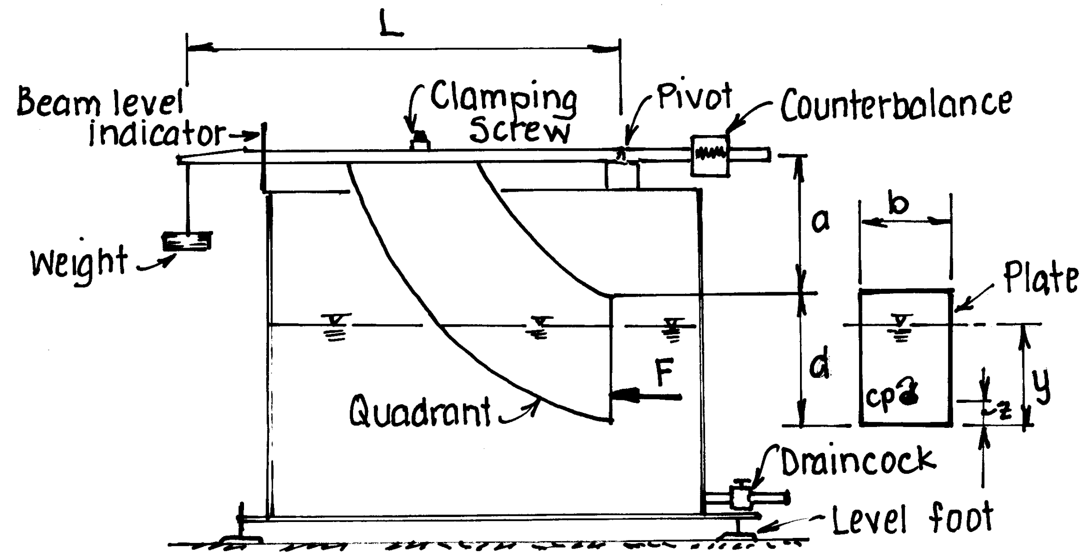

Figure 1-1 Hydrostatic Pressure Apparatus

Procedure:

1. Place the quadrant on the two dowel pins and, using clamping screw, fasten it to the balance arm.
2. Level the Plexiglas tank by adjusting the screwed feet. The level is indicated on the circular spirit level.
3. Hang the balance pan and make the balance arm horizontal by moving the counter balance weight.
4. Measure a, L, d, b as shown in Figure 1-1.
5. Close the drain cock and fill the tank with water until the water level reaches the bottom edge of the quadrant. Level the arm by moving the counterbalance weight.
6. Place 50 grams on the balance pan and slowly add water to the tank until the balance arm is again horizontal. Record the water level (y) on the quadrant and the weight on the balance pan (W = mg).

7. Repeat Step 6 for several increments placing about 50 grams on the balance pan for each step until the water level reaches the top of the quadrant end face. Repeat Step 6 one more time so that the quadrant end face is totally submerged for this last run.
8. Remove each increment of weight and allow the water to drain until the balance arm is level. Note the weights and water levels for each increment as the weights are removed.

Interpretation of Results:

You want to find the center of pressure on the plate for each reading taken during filling and draining the tank. To do this, take moments about the pivot. Thus,

$$-mg(L) + F(a + d - z) = 0 \quad (1\text{-}1)$$

in which z = the height of the center of pressure above the bottom of the plate. The force on the submerged plate is given by,

$$F = \rho g \bar{y} A \text{ with } \bar{y} = \frac{1}{2} y \text{ and } A = by \quad (1\text{-}2)$$

Therefore,

$$F = \rho g b \frac{y^2}{2} \quad (1\text{-}3)$$

Substituting,

$$-mg(L) + \left(\frac{\rho g y^2 b}{2} \right)(a + d - z) = 0 \quad (1\text{-}4)$$

Solving for z we get,

$$z = a + d - \frac{2mL}{\rho y^2 b} \quad (1\text{-}5)$$

Note that ρ = 1 gm/cm^3 or 1000 kg/m^3.

For each of the readings obtained during filling and draining the tank calculate the height above the bottom of the plate of the center of pressure (z) and plot the calculated values of z against y. Fit a straight line to the data.

Questions:

1. What is the slope of the straight line?
2. How far above the bottom of the plate should the center of pressure be?

3. Theoretically, what should the value of the slope be? Did you get this value? If not, why not?
4. If the plate had been an isosceles triangle with its base at the bottom, what would the theoretical slope of the line be?

Data:

Water temperature=

a= 10.2 cm; L=27.5 cm; d= 10.0 cm; b=7.5 cm

Tank Filling		Tank Draining	
m (gm)	y (cm)	m (gm)	y (cm)