LAB 3 – CENTER OF PRESSURE ON PARTIALLY AND FULLY SUBMERGED SURFACES

LEARNING OUTCOMES

1. Describe the pressure distribution on partially and fully submerged surface
2. Compute the hydrostatic force and the location of center of pressure
3. Measure the hydrostatic force and the location of center of pressure

In this experiment, we will use a hydrostatic pressure apparatus (shown in Figure 1) with the Armfield Hydraulic Bench to determine the hydrostatic force and center of pressure on partially submerged and fully submerged plane surface. We will also compute the theoretical location of the center of pressure and compare it with the experimentally measured value.

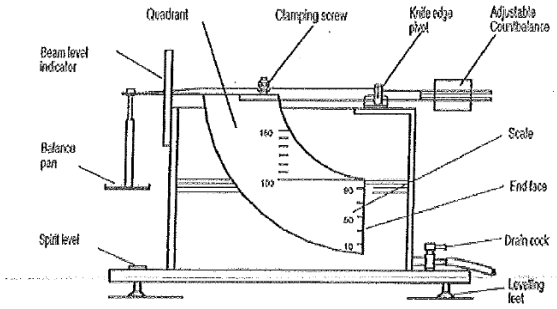

Figure 1. Schematic diagram of the hydraulic bench apparatus

EXPERIMENTAL PROCEDURE

1. Place the empty tank on the Bench and position the balance arm on the pivot. Place the balance pan in the grove at the end of the balance arm. Level the tank and position the counterbalance weight until the balance arm is horizontal
2. Close the drain and fill the glass tank with the water until it is full
3. Add weights to ensure the balance arm is horizontal. (Note: It is easier to drain the tank so overfill the tank and slowly drain the water until the arm is horizontal)
4. When the arm is level, it means the force on the vertical face of the quadrant balances out due to the added weight
5. Read the depth of immersion from the scale on the face of the quadrant
6. Repeat the steps 3-5 by removing the weight and draining the tank until the arm is horizontal again
7. Try to get at least 3-4 measurements for fully submerged and partially submerged surfaces

DATA ANALYSIS

Partially submerged surfaces

The key dimensions of a partially submerged surface are shown in Figure 2. The width of the quadrant (B) is 0.075 m, height of the quadrant (D) is 0.1 m, length of the balance (L) is 0.275 m, and the distance from quadrant to pivot (H) is 0.2 m.

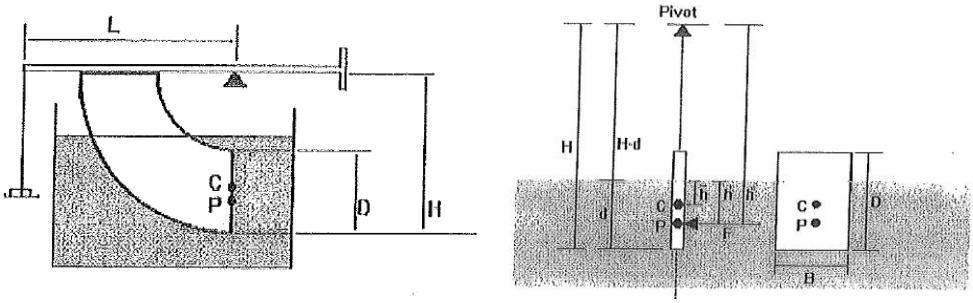

Figure 2. Illustration showing the key dimensions of a partially submerged surface. (Note: d is the depth of submersion, F is the hydrostatic force, h is the depth of the centroid, h' is depth to the center of pressure, h'' is the distance to the line of action of thrust below the pivot)

The hydrostatic force (F) is given

$$F = \gamma \frac{Bd^2}{2} \quad (1)$$

Where γ is the specific weight of water, B is the width of quadrant, and d is the depth of immersion

The experimental location of the force (h''_{exp}) is given by

$$h''_{exp} = \frac{mgL}{F} \quad (2)$$

Where m is the mass added, g is the gravitational constant, L is the length of the balance and F is hydrostatic force

The theoretical location of the force ($h''_{theoretical}$) is given by

$$h''_{theoretical} = H - \frac{d}{3} \quad (3)$$

Where H is the distance from quadrant to pivot.

Fully submerged surfaces

The key dimensions of a fully submerged surface are shown in Figure 3.

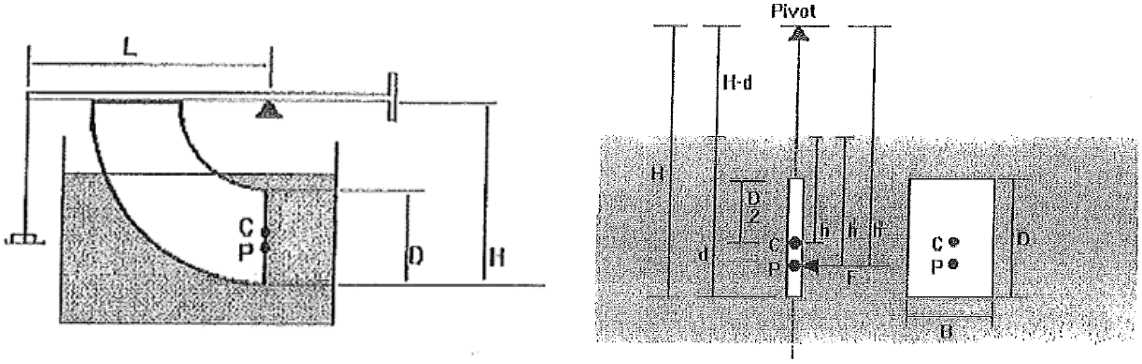

Figure 3. Illustration showing the key dimensions of a fully submerged surface

The hydrostatic force (F) is given

$$F = \gamma BD\left(d - \frac{D}{2}\right) \quad (4)$$

Where the specific weight of water, B is the width of quadrant, d is the depth of immersion and D is the height of the quadrant.

The experimental location of the force (h''_{exp}) is given by

$$h''_{exp} = \frac{mL}{\rho BD\left(d - \frac{D}{2}\right)} \quad (5)$$

Where m is the mass added, L is the length of the balance, and ρ is the density of water

The theoretical location of the force ($h''_{theoretical}$) is given by

$$h''_{theoretical} = \frac{\frac{D^2}{12} + \left(d - \frac{D}{2}\right)^2}{d - \frac{D}{2}} + H - d \quad (6)$$

Where H is the distance from quadrant to pivot.

DELIVERABLES

One team lab report containing the following

1. Letter of Transmittal (example: http://users.rowan.edu/~jagadish/resources/LoT_Example.pdf)
2. Introduction
3. Materials and Methods
    a. In paragraph format explain what materials you used
    b. Explain the procedure for collecting data in your own words in paragraph format
    c. Explain the method for analyzing the data collected in lab by separating into two sections. Retype all the equations, screenshotting is not permitted. Use subscripts and superscript where necessary
4. Results and Discussion
    a. Separate into two sections for partially and fully submerged
    b. Explain your results for each section including tables
    c. Compare the theoretical and experimental for location of center of pressure for each section.
    d. Discuss the error associated with measurement. Where is error introduced? Are the instruments you used accurate? What is the lower significant digit this instrument can measure?

4. Conclusions
    a. Briefly summarize your results and explain what you learned.