

Faculty of Engineering and Technology

Mechanical Engineering Department

Fluid Mechanics Laboratory

ENME 312

**Exp1: “The Center of Pressure”**

**Done by :**

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1. **Abstract**

 The center of pressure can be defined as the point where the total sum of a pressure field acts on a body, causing a force to act through this point. The total force vector acting at the center of pressure is the value of the integrated pressure field. The resultant force and center of pressure location produce equivalent force and moment on the body as the original pressure field. In this lab experiment, the moment due to the total fluid thrust on a wholly or partially submerged plane surface is to be measured and compared with theoretical analysis. Two angular settings are used to carry out the experiment (θ=0 °and θ=20°) for both partially submerged (h>R 1 cos θ) and fully submerged (h<R 1 cos θ). For θ=0° the quadrant is balanced until the jockey weight is adjusted. Then the weight hanger (50g) is placed in position at the end of the arm. Water is poured into the quadrant until balanced is restored and the depth of water (from the horizontal 0 to the water surface) is recorded. By referring to the data sheet, weights are added in increments and the depth of water is recorded each time. These steps are repeated for θ=20°.

1. **Objectives**

The main objectives of this experiment:

* To understand the hydrostatic force distribution on the plane surface. Understanding this concept is very important for designing hydrostatic structures such as dams.
* To determine the center of pressure of the plane surface and the hydrostatic force.
* To determine the moment due to the total fluid thrust on a wholly or partially submerged plane surface and comparing it with theoretical analysis.
* To determine the specific weight of the fluid from the graphs.
1. **Sample Calculation**

**For ϴ = 0:**R1cosϴ=100

h > 100 mm, Partially submerged

h < 100 mm, fully submerged

**for partially submerged:**

weight =50g, height= 156mm

moment (M) calculated by using, M=m\*g\*d,

 where:

moment in N/m

mass in kg.

 g (gravity)=9.81 m/s2

d=0.25 m

M=0.05\* 9.81\*0.25 =0.1226 N/m

**For fully submerged**:

 weight =250g, height= 96mm

moment (M) calculated by using, M=m\*g\*d,

 where:

moment in N/m

mass in kg.

 g (gravity)=9.81 m/s2

d=0.25 m

M=0.25\* 9.81\*0.25 =0.613 N/m

Ycp= $\frac{M}{F}$

Force was calculated using:

F = $\frac{γ\_{avg}×B×COSθ}{2}(R\_{2}^{2}- R\_{1}^{2})$

Where B=0.075m,$ R\_{2}^{}=0.2 m $,$ R\_{1}^{}=0.1 m$

$$γ\_{1}=147.29$$

$$γ\_{2}=11.589$$

$$γ\_{avg}=79.439$$

F = $\frac{γ\_{avg}×B×COSθ}{2}(R\_{2}^{2}- R\_{1}^{2})$

F = $\frac{79.439×0.075×1}{2}(0.2\_{2}^{2}- 0.1\_{1}^{2})$ = 0.0893 N

Ycp= $\frac{0.1226 }{0.0893 }=1.373 m$ ,for partially

Ycp= $\frac{0.613 }{0.0893}$ = 6.859 m, for fully

**For ϴ = 20:**
R1cosϴ=93.97

h > 93.97 mm, Partially submerged

h < 93.97 mm, fully submerged

**for partially submerged:**

weight =20g, height= 158mm

moment (M) calculated by using, M=m\*g\*d,

 where:

moment in N/m

mass in kg.

 g (gravity)=9.81 m/s2

d=0.25 m

M=0.02\* 9.81\*0.25 =0.04905 N/m

**For fully submerged**:

weight =240g, height= 90mm

M=0.25\* 9.81\*0.25 =0.5886 N/m

Ycp= $\frac{M}{F}$

F = $\frac{γ\_{avg}×B×COSθ}{2}(R\_{2}^{2}- R\_{1}^{2})$ , Where B=0.075,$ R\_{2}^{}=0.2 m $,$ R\_{1}^{}=0.1 m$

$$γ\_{1}=147.39$$

$$γ\_{2}=11.568$$

$$γ\_{avg}=79.48$$

F = $\frac{γ\_{avg}×B×COSθ}{2}(R\_{2}^{2}- R\_{1}^{2})$

F = $\frac{79.439×0.075×1}{2}(0.2\_{2}^{2}- 0.1\_{1}^{2})$ = 0.0894 N

Ycp= $\frac{0.04905 }{0.0894 }=0.548m$ ,for partially

Ycp= $\frac{0.5886 }{0.0894}$ = 6.584 m, for fully submerged.

**Results**

Table1: (for ϴ = 0) the mass in g, height in m, and moment(M)in N.m.

|  |  |  |  |
| --- | --- | --- | --- |
| weight | h | h(m) | M |
| 50 | 156 | 0.156 | 0.131996 |
| 70 | 148 | 0.148 | 0.181705 |
| 90 | 140 | 0.14 | 0.238383 |
| 110 | 132 | 0.132 | 0.301654 |
| 130 | 126 | 0.126 | 0.353206 |
| 150 | 120 | 0.12 | 0.408096 |
| 180 | 112 | 0.112 | 0.486199 |
| 200 | 106 | 0.106 | 0.548258 |
| 250 | 96 | 0.096 | 0.65727 |
| 270 | 92 | 0.092 | 0.701415 |
| 290 | 86 | 0.086 | 0.767633 |
| 310 | 82 | 0.082 | 0.811778 |
| 330 | 78 | 0.078 | 0.855923 |
| 350 | 74 | 0.074 | 0.900068 |
| 380 | 68 | 0.068 | 0.966285 |
| 400 | 62 | 0.062 | 1.032503 |

Table2: for ϴ = 20: the mass in g, height in m, h^3 in m^3,and moment(M)in N.m.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Weight | h | h(m) | M | h^3 |
| 20 | 158 | 0.158 | 0.107782 | 0.003944 |
| 40 | 146 | 0.146 | 0.174339 | 0.003112 |
| 60 | 138 | 0.138 | 0.226454 | 0.002628 |
| 90 | 128 | 0.128 | 0.299718 | 0.002097 |
| 110 | 120 | 0.12 | 0.364416 | 0.001728 |
| 160 | 108 | 0.108 | 0.470818 | 0.00126 |
| 180 | 102 | 0.102 | 0.527922 | 0.001061 |
| 200 | 98 | 0.098 | 0.56721 | 0.000941 |
| 220 | 92 | 0.092 | 0.62634 | 0.000779 |
| 240 | 90 | 0.09 | 0.64605 | 0.000729 |
| 260 | 84 | 0.084 | 0.70518 | 0.000593 |
| 290 | 78 | 0.078 | 0.76431 | 0.000475 |
| 310 | 74 | 0.074 | 0.80373 | 0.000405 |
| 360 | 64 | 0.064 | 0.90228 | 0.000262 |
| 380 | 58 | 0.058 | 0.96141 | 0.000195 |
| 400 | 54 | 0.054 | 1.00083 | 0.000157 |

Graph 1: M VS. hfor θ=0degree

Graph 2: M VS. h3 for θ=20 degree

1. **Discussion of results**

 Using the graph of the moment versus the different heights, we can find the slope, which is equal to the specific weight of the fluid (water). The relationship between the moment and the height and the moment and the height cubed can be approximated as linear and are linear, respectively. This means that our results are close to the theoretical values, and thus are acceptable. The specific weight in this case is slightly over 1000 N/m3

1. **Conclusion**

 It can be concluded that the fluid confined behind a surface exerts a force on it, this force depends on the fluid density, the level of fluid, and the shape and position of the surface. This force acts on the center of pressure of the surface. Knowing the value of the force and its point of action helps us in designing the dams, gates, reservoir, etc.

**Sources of error**

• Inaccuracy in reading the water level (h).

• Incorrect balance of the angle while adding the weights and water.

**Appendices:**

* **Data Sheet:**

Data sheet is attached at the end of the report.

* **References:**
1. Fluid Mechanics Lab Manual.
2. Currie, I.G., 2012. Fundamental Mechanics of Fluids, 4th Edition. Boca Raton, FL: CRC Press