NORTH SOUTH UNIVERSITY

Center of Excellence in Higher Education

The First Private University in Bangladesh

Department of

CIVIL AND ENVIRONMENTAL ENGINEERING

CEE211L Fluid Mechanics Lab

WATER RESOURCES ENGINEERING LABORATORY

NORTH SOUTH UNIVERSITY

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North South University
Department of Civil and Environmental Engineering

CEE211L: FLUID MECHANICS LAB

Experiment No.	Name of the Experiment
1	Bernoulli's Theorem
2	Flow through Venturimeter
3	Flow through an Orifice
4	Flow through an external Mouthpiece
5	Fluid Friction in a pipe
6	Flow over a V-notch
7	Centre of Pressure
8	Flow over a Sharp-Crested Rectangular Weir

North South University
Department of Civil and Environmental Engineering

CEE 211L FLUID MECHANICS LAB
WORKBOOKS FOR LABORATORY PRACTICE

EXPERIMENT NO: 01
BERNOULLI'S THEOREM

Name:

ID:

Group:

Section:

Performance Date:

Submission Date:

EXPERIMENT NO: 01
BERNOULLI'S THEOREM

Objective:

1. To plot the static head, velocity head and total head against the length of the passage in a plain graph paper.
2. To plot the total head loss against the inlet kinematic head for different inflow conditions in a plain graph paper.

General:

Energy is the ability to do work. It manifests in various forms and can change from one form to another. The various forms of energy present in fluid flow are elevation, kinetic, pressure and internal energies. Internal energies are developed due to molecular agitation and manifested by temperature. Heat energy may be added to or subtracted from a flowing fluid through the wall of the tube, or mechanical energy may be added to or subtracted from the fluid by a pump or turbine. Daniel Bernoulli in the year 1938 stated that in a steady flow system of frictionless (or non-viscous) incompressible fluid, the sum of pressure, elevation and velocity heads remains constant at every section, provided no energy is added to or taken out by an external source.

Practical application:

Bernoulli's Energy equation can be applied in practices for the construction of flow measuring devices such as Venturimeter, flow nozzle, orifice meter and pitot tube, Furthermore, it can be applied to the problems of flow under a sluice gate, free liquid jet, radial flow and free vortex motion. It can also be applied to real incompressible fluids with good results in situations where frictional effects are very small.

Theory:

Assuming frictionless flow, Bernoulli's theorem states that, for a horizontal conduit

$$\frac{P_1}{\gamma} + \frac{V_1^2}{2g} = \frac{P_2}{\gamma} + \frac{V_2^2}{2g} = \frac{P_3}{\gamma} + \frac{V_3^2}{2g} = \cdots \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.(1)$$

Where,

P_1, P_2 = Pressure of flowing fluid at section 1 and 2

γ = Unit weight of fluid

V_1, V_2 = mean velocity of flow at section 1 and 2

g = Acceleration due to gravity.

For actual condition there must be some head loss in the direction of flow. Bernoulli's theorem for a steady flow of a frictionless, incompressible fluid, states that head along a streamline remains constant. For an irrotational flow it means that the total head is constant between section 1 and 2 and it is, h_L then Bernoulli's theorem is modified to

$$\frac{P_1}{\gamma} + \frac{V_1^2}{2g} = \frac{P_2}{\gamma} + \frac{V_2^2}{2g} + h_L$$

Description of Apparatus:

Bernoulli's Theorem apparatus is a self-contained, compact closed circuit set-up in hydraulics laboratory. It consists of a sump tank, measuring tank and monoblock pump along with necessary piping. Water is delivered to the set-up by a motorized pump.

- The apparatus consists of an inlet tank and outlet tank connected by a flow channel.
- The channel tapers for a length and gradually enlarges in a length.
- On the top of a flow channel scale are fixed at a distance, center to center for the measurement of pressure head.
- To regulate the flow into the inlet tank, a valve is provided.
- Flow can be obtained by controlling suitable inlet valve. After a while, a steady state will be reached.

Sr. No.	Name	Specifications	Qty.
1	No. of tubes	9 nos.	
2	**Pressure Tapping No.**	**C/S Diameter (meter)**	
	1	0.0223	
	2	0.0214	
	3	0.0202	
	4	0.0194	
	5	0.0152	
	6	0.0194	
	7	0.0202	
	8	0.0214	
	9	0.0223	

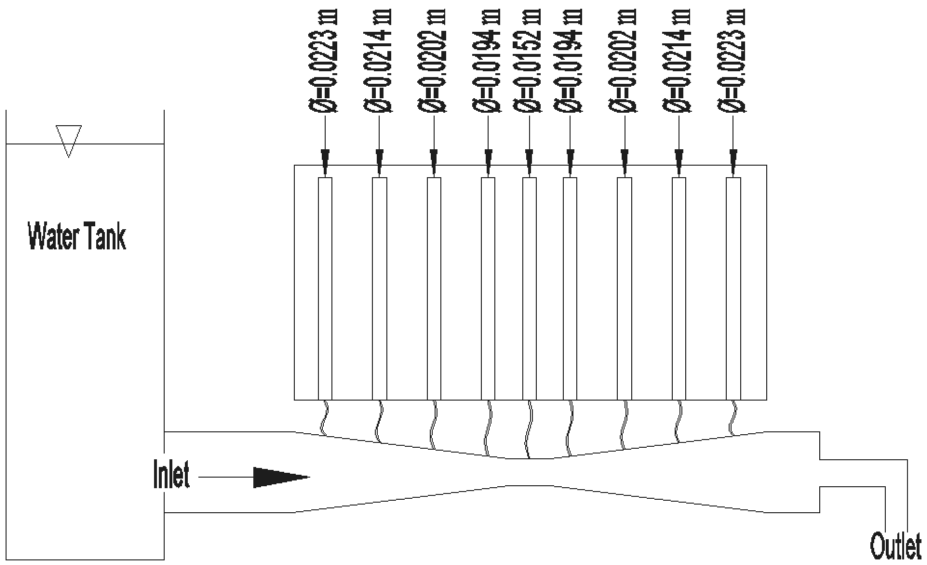

Fig: Bernoulli's Theorem Apparatus

Procedure:

1. Fill the sump tank by sufficient water.
2. Now press the power button to On position.
3. Outlet valve can be kept closed and the water level in the inlet tank will rise and that in the piezometer tubes will simultaneously rise, as there is no flow.
4. When the outlet valve is opened and steady state is reached, the pressure head at different points along the flow can be recorded.
5. To determine the steady discharge, set the discharge for different LPH (Liter per Hour) calculated by measuring tank.
6. From area table supplied, cross sectional areas of the flow channel corresponding to piezometers can be determined.
7. From the discharge and area, velocity tapings can be found out; visual observation of the pressure heads indicates that a parabolic curve is obtained.
8. However observations for a few discharge variations can be recorded, and following calculations and table can be prepared for a variation of the theorem.

Practice Questions:

1. What are the assumptions underlying the Bernoulli's energy equation?
2. Do you need any modifications of Eqn(1) when (a) The frictional head loss is to be considered, and (b) the conduit is not horizontal?
3. What is the difference between energy line and energy grade line?

For Calculation:

Area, $A = \frac{\pi}{4}D^2$

Discharge,

$\mathbf{Q_{actual}} = \frac{Volume\ of\ water}{Time} = \frac{Liter\ x\ 1000}{t}$ cm^3/sec

$\mathbf{Q_t}$ = AV

Velocity, Va = $(\frac{\mathbf{Qactual}}{\mathbf{A}})$

Vt = $(\frac{\mathbf{Qt}}{\mathbf{A}})$

- ★ $\mathbf{Q_a}$ = Actual Discharge
- ★ $\mathbf{Q_t}$ = Theoretical Discharge

EXPERIMENT NO 01
Bernoulli's Theorem
Experimental Data and Calculation Sheet

OBSERVATION DATA & RESULT SHEET:

Tube No.	Dia of Tube (cm)	Manometer Reading/ Pressure head ($\frac{P}{\gamma}$) (cm)	Time required (t) for 2 liter raise in water level (Sec)	Actual discharge Q cm^3/sec	Area of Tube $A = \frac{\pi d^2}{4}$ (cm^2)	Velocity V=Q/A (cm/sec)	Velocity head = ($\frac{V^2}{2g}$) (cm)	Total head H=($\frac{P}{\gamma} + \frac{V^2}{2g}$) (cm)	Head loss $h_L = (H_1 - H_9)$ (cm)
1	2.23								
2	2.14								
3	2.02								
4	1.94								
5	1.52								
6	1.94								
7	2.02								
8	2.14								
9	2.23								

Group No.	1	2	3	4	5	6	7	8
$\frac{V1^2}{2g}$								
h_L								

ID: ………………………………………..

Group:…………………………………

Section:…………………………………

Performance Date:……………………

Signature of the Teacher

NB: Use extra pages for calculation & Discussion.

North South University
Department of Civil and Environmental Engineering

CEE 211L FLUID MECHANICS LAB
WORKBOOKS FOR LABORATORY PRACTICE

EXPERIMENT NO: 02
FLOW THROUGH VENTURIMETER

Name:

ID:

Group:

Section:

Performance Date:

Submission Date:

EXPERIMENT NO: 02
FLOW THROUGH VENTURIMETER

Objective:

1. To find out the coefficient of discharge C_d for the Venturimeter.
2. To plot Q_a against H in log-log paper to find (a) the exponent of H, and (b) C_d
3. To calibrate the Venturimeter.

General:

The conversing tube is an efficient device for converting pressure head to velocity head, while the diverging tube converts velocity head to pressure head. The two may be combined to form a venture tube. As there is a definite relation between the pressure differential and the rate of flow, the tube may be made to serve as metering device. Venturimeter consists of a tube with a constricted throat that produces an increased velocity accompanied by a reduction in pressure followed by a gradual diverging portion in which velocity is transformed back into pressure with slight friction loss.

Practical application:

The Venturimeter is used for measuring the rate of flow of both compressible and incompressible fluids. The Venturimeter provides an accurate means for measuring flow in pipelines.

Theory:

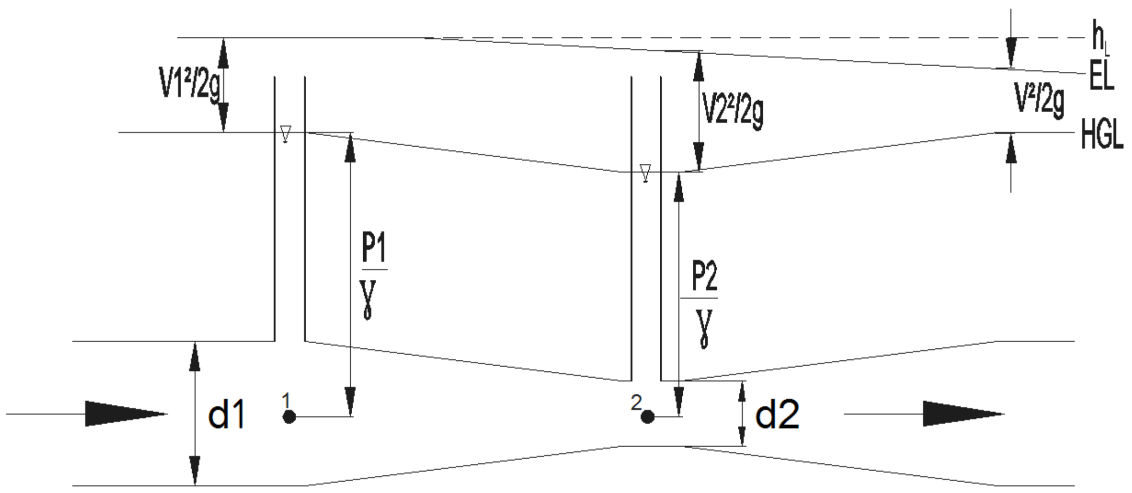

Fig: Flow through a Venturimeter

Consider the Venturimeter shown in the above figure. Applying the Bernoulli's equation between point 1 as a inlet and point 2 as throat, we can write

$$\frac{P1}{\gamma}+\frac{V1^2}{2g}=\frac{P2}{\gamma}+\frac{V2^2}{2g} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (1)$$

Where,

P_1, P_2 = Pressure of flowing fluid at section 1 and 2

γ = Unit weight of fluid

V_1, V_2 = mean velocity of flow at section 1 and 2 g = Acceleration due to gravity.

From the continuity equation, we have

$$A_1V_1 = A_2V_2 \quad \ldots\ldots(2)$$

Where,

$A_{1,}$ = Cross-sectional area of the inlet

A_2 =Cross-sectional area of the throat, respectively.

$A_1 = \frac{\pi}{4} d_1^2$, $A_1 = \frac{\pi}{4} d_1^2$

From equation (1) and (2)

$$V_1 = \sqrt{\frac{2g}{\left(\frac{d1}{d2}\right)^4 - 1} \text{ x } \frac{(P1-P2)}{\gamma}}$$

So,

$$V_1 = K_1 H^{1/2} \quad \ldots\ldots(3)$$

Let, $K_1 = \sqrt{\frac{2g}{\left(\frac{d1}{d2}\right)^4 - 1}}$ and, $H = \frac{(P1-P2)}{\gamma}$

Now the theoretical discharge,

$$Q_t = \frac{A_1 X A_2}{\sqrt{(A_1^2 - A_2^2)}} * \sqrt{2gH}$$

Again,

$$Q_t = A_1V_1$$
$$= A_1 K_1 H^{1/2}$$
$$= K H^{1/2}$$

So,

$$Q_t = K H^{1/2} \quad \ldots\ldots(4)$$

Where,

$$K = A_1K_1 \quad \ldots\ldots(5)$$

Coefficient of discharge, (Cd)

It is the ratio of actual discharge through the Venturimeter to theoretical discharge neglecting friction losses. So, if the actual discharge is $Q_{a,}$

[$\mathbf{Q_{actual}} = \frac{Volume\ of\ water}{Time} = \frac{Liter\ X\ 1000}{t}$ cm^3/sec] and the theoretical discharge is Q_t then coefficient of discharge,

$$Cd = \frac{Qa}{Qt}$$

$$Q_a = C_d Q_t$$

$$= C_d K\, H^{1/2}$$

$$= C\, H^n$$

So,

$$Q_a = C\, H^n \quad \ldots\ldots(6)$$

The value of Cd may be assumed to be about 0.99 for large meter and about 0.97 or 0.98 for small ones provided the flow is such as to give reasonably high Reynolds number.

Calibration:

One of the objectives of the experiment is to find the values of C and n for a particular meter. So that in future we can measure actual discharge only by measuring H. Here C and n are called calibration parameters.

For 5/6 sets of actual discharge and H data we plot Qa vs H in log-log paper and draw a best –ft straight line. The equation of line is

$$\log Q_a = \log C\, H^n$$

$$\Rightarrow \log Q_a = \log C + n \log H \quad \ldots\ldots(7)$$

Now from the plotting we take two points on the straight line say (H_1, Q_{a1}) and (H_2, Q_{a2})

So, from equation (7) we get

$$\log Q_{a1} = \log C + n \log H_1$$

$$\log Q_{a2} = \log C + n \log H_2$$

Solving, $$n = \frac{\log\left(\frac{Qa1}{Qa2}\right)}{\log\left(\frac{H1}{H2}\right)}$$

$$C = \text{antilog}\,(\log Q_{a1} - n \log H_1)$$

So, the calibration equation is, $Q_a = C\, H^n$

Now $C = C_d\, K$ $\quad \Rightarrow C_d = \frac{C}{K}$

Now from the calibration equation we can calculate actual discharge for a different H and plot on a plain graph paper. In practice we can use the plot to find actual discharge for any H. Thus the Venturimeter is calibrated.

Description of Apparatus:

- The apparatus consists of a Venturimeter fitted in a pipeline. The pipeline is taken out from a common inlet.
- Pressure tapping are taken out from the inlet and the throat of the Venturimeter are to be connected to separate manifold
- The measuring tank is provided to measure the actual discharge.

Procedure:

1. Fill the sump tank by sufficient water.

2. Place the required assembly and add the hose nipple to QRC.
3. Now check the inlet VALVE1 in full clockwise direction.
4. Open both the bypass valve and close all small ball valve of manifold.
5. Now press the MAINS button to ON position.
6. Close the outlet valve of Orifice meter and Open the outlet valve of Venturimeter.
7. Also close all small ball valves of manifold. Only open for Venturimeter connected ball valves – VMP1 & VMP2
8. Now also connect the pipes from P1 and P2 of manifold to P1 & P2 of pressure gauge manifold. Also all three small ball valves of pressure gauge manifold are closed.
9. Give some back pressure with the help of closing the bypass valve of Venturimeter pipe slowly.
10. Open ball valves for P1 and DRAIN. Close the DRAIN. Note down the value of P1 in PSI. Close P1. Open P2 and DRAIN. Close ball valve DRAIN and note down the value of P2 in psi.
11. Same time close the VALVE2 for measuring the water level
12. Keep stopwatch in hand and take the time intervals for 5 liter water level height. Better when water reaches to 15 liter mark start the stopwatch and when reach the 20 liter mark stop the stopwatch and open the VALVE2.
13. Change the discharge through Venturimeter pipe by operating bypass valve and repeat the above procedure to obtain different observations.

Practice Questions:

1. Why is the diverging angle smaller than the converging angle for a Venturimeter?
2. How can the accuracy of Venturimeter be increased in use?
3. On what factors does the Venturimeter co-efficient depend?

EXPERIMENT NO: 02
Flow through Venturimeter
Experimental Data and Calculation Sheet

OBSERVATIONS:

Diameter at the inlet of the Venturimeter d1 = 28.0 mm = 2.8 cm
Diameter at the throat of the Venturimeter d2 = 14.5 mm = 1.45 cm
Acceleration due to gravity, g = 9.81 m/ sec^2 = 981 cm/ sec^2
1 psi = (10.19744316 X 0.0689476) = 0.7031 mtr of water = 70.31 cm of water.

OBSERVATION TABLE:

Sl. No./Gr. No.	P1 (Psi)	P2 (Psi)	Time required (t) for 5 liter raise in water level (Sec)	Head difference H = (P x 70.31) (cm)	Actual discharge Q_a (cm^3/sec)	K_1	K	Theoretical discharge Q_t (cm^3/sec)	Coefficient of discharge $C_d = \frac{Q_a}{Q_t}$	$V_2 = \frac{Q_a}{A_2}$	Reynolds number R

ID: …………………………………………..

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Section:……………………………………

Performance Date:……………………….

Signature of the Teacher

NB: Use extra pages for calculation & Discussion.

North South University
Department of Civil and Environmental Engineering

CEE 211L FLUID MECHANICS LAB
WORKBOOKS FOR LABORATORY PRACTICE

EXPERIMENT NO: 03
FLOW THROUGH AN ORIFICE

Name:

ID:

Group:

Section:

Performance Date:

Submission Date:

EXPERIMENT NO: 03
FLOW THROUGH AN ORIFICE

Objective:

1. To determine the coefficient of discharge C_d
2. Coefficient of velocity C_v and
3. Coefficient of contraction Cc for the Orifice.
4. To find the head loss, H_L
5. To plot Q_a vs H in log-log paper and to find (a) the exponent of H and (b) C_d
6. To plot V_a vs H in log-log paper and to find (a) C_v and (b) the exponent of H

General:

An orifice is an opening in the wall of a tank or in a plate normal to the axis of a pipe, the plate being either at the end of pipe or in some intermediate location. An orifice is characterized by the fact that the thickness of the wall or plate is very small relative to the size of the opening. For a standard orifice there is only a line contact with fluid.

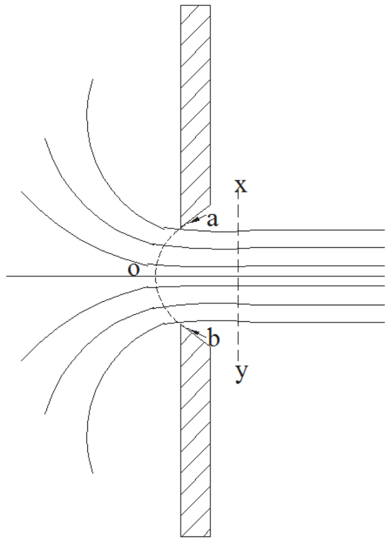

Fig.-1: Jet contraction

Where the streamlines converge in approaching an orifice, they continue to converge beyond the upstream section of the orifice until they reach the section xy where they become parallel. Commonly this section is about 0.5D from the upstream edges of the opening, where D is the diameter of the orifice. The section xy is then a section of minimum area and is called the vena contracta. Beyond the vena contracta the streamlines commonly diverge because of frictional effects.

Practical application:

The usual purpose of an orifice is the measurement or control of flow from a reservoir. The orifice is frequently encountered in engineering practice operating under a static head where it is usually not used for metering but rather as a special feature in a hydraulic design. Another problem of orifice flow, which frequently arises in engineering practice, is that of discharge from an orifice under falling head, a problem of unsteady flow.

Description of Apparatus:

This is a self- contained, compact, closed circuit set-up in hydraulics laboratory. It consists of a tank, mono-block pump and a measuring tank along with necessary piping.

A measuring flask (2 liter) is provided for flow measurement. After measuring the water discharge at specific time intervals, water in the measuring flask is released into measuring tank. Further all water released to sump tank by opening the valve2.

Specification:

- Orifice : 10 Ø – 1 no.
  7 Ø – 1 no.
- Measuring Flask: 2 Liters.

Theory:

Coefficient of contraction (Cc):

The ratio of the area of a jet at the vena contracta to the area of the orifice is called the coefficient of contraction.

$$C_c = \frac{A_a}{A}$$

Coefficient of velocity (C_v):

The velocity that would be attained in the jet if the friction did not exist may be termed to the theoretical velocity. The ratio of actual velocity to the theoretical velocity is called coefficient of velocity.

$$C_v = \frac{V_a}{V_t}$$

Coefficient of discharge (C_d):

The ratio of actual rate of discharge to the theoretical rate of discharge (the flow that would occur if there were no friction and no contraction) is called coefficient of discharge.

$$C_d = \frac{Q_a}{Q_t}$$

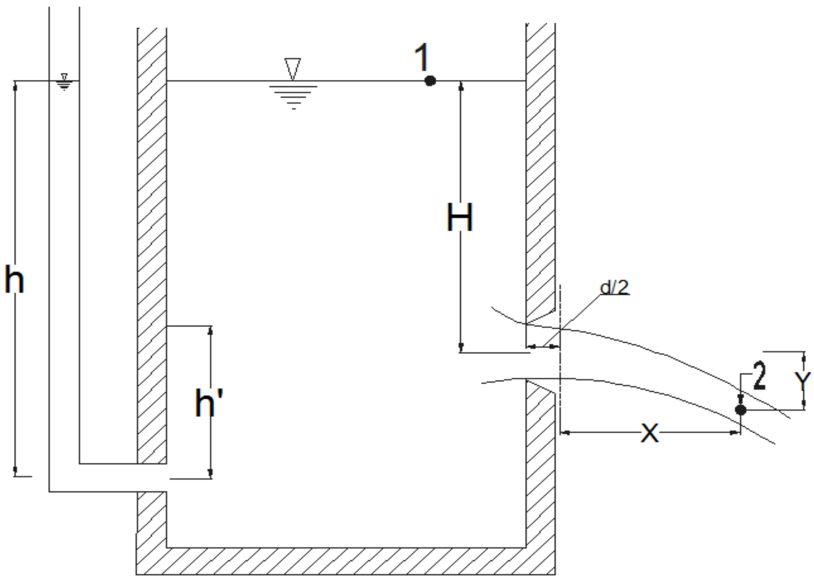

Fig.-2: Flow through an orifice

Consider a small orifice having a cross-sectional area A and discharging water under a constant head H as shown in the above figure. Applying Bernoulli's theorem between point 1 & 2

$$H = 0 + \frac{V^2}{2g}$$

So, $V_t = \sqrt{2gH}$

Where, g is the acceleration due to gravity.

So, theoretical discharge Q_t is given by

$$Q_t = A\sqrt{2gH}$$

Let Qa be the actual discharge.

Then the Coefficient of discharge, (C_d) is given by

$$C_d = \frac{Q_a}{Q_t}$$

Coefficient of velocity (C_v) by the coordinate method:

Let H be the total head causing flow through an orifice with vena contracta as shown in above figure. The jet of the water has horizontal velocity but is acted upon by gravity with a downward acceleration of g. Let us consider a particle of water in the jet at P and let the time taken for this particle to move O to P be t.

Let x and y be the horizontal and vertical co-ordinates of P respectively. Then

$x = V_a t$

and

$y = \frac{1}{2} g t^2$

Equating the values of t^2 from these two equations, one obtains

$$\frac{x^2}{V_a^2} = \frac{2y}{g}$$

Or, $V_a = \sqrt{\frac{gx^2}{2y}}$

But the theoretical velocity, $V_t = \sqrt{2gH}$

Hence, the coefficient of velocity is,

$C_v = \frac{V_a}{V_t} = \sqrt{\frac{x^2}{4yH}}$ and the head loss is given by

$$H_L = \left(1 - {C_V}^2\right) H$$

Cc = Coefficient of contraction = $\frac{A_a}{A}$

It follows that

$$C_d = C_v \times C_c$$

Procedure:

1. Fill the sump tank by sufficient water.
2. Place the required assembly and add the hose nipple to QRC.
3. Also attach the required orifice. Loose the knobs to add the pointers and after then tight the knobs.
4. Now check the inlet VALVE1 in full clockwise direction.
5. Now press the MAINS button to ON position.
6. Allow the water to rise to any constant level. (For quick rise of water in the tank, the orifice may be closed by hands)
7. Deliver the overflow water into the drain directly by a PVC pipe connection. Adjust this pipe by hand to maintain the constant head over the centerline.
8. Wait for some time. After that Record 'h' i.e. head over the centerline of the orifice in mm.
9. Adjust the all pointed tip of the rod at the center of the jet to touch the water flowing through orifice.
10. Measure all the Y-coordinates in mm with the steel scale from the center of the knob to the water touching line.
11. Also measure all the X-coordinates in mm each difference is 25mm.
12. Same process repeat for another .
13. To vary the head over the orifice, raise or lower the overflow pipe.
14. During the experiment, ensure that the water overflows continuously through the pipe.

Practice Questions:

1. What are the coefficient of velocity, Coefficient of contraction, coefficient of discharge for an orifice? On what factors do these coefficients depend?
2. What is a submerge orifice? What are the average values of the coefficient of velocity, Coefficient of contraction, coefficient of discharge for a submerged orifice?
3. Why is the actual discharge through an orifice less than the theoretical discharge?
4. Define vena contracta. Why does it form?
5. Will the value of Cv be different for sharp-edged and rounded orifices? Why?

EXPERIMENT NO: 03
Flow through an Orifice
Experimental Data and Calculation Sheet

OBSERVATIONS:

Diameter of the Orifice **d = 10 mm = 1.0cm**
X-Coordinate start point = **48 mm**
Y-Coordinate start point = **50 mm**

OBSERVATION TABLE:

Sl. No.	Head (H) over the center line (cm)	X-Coordinate (mm)	Y-Coordinate (mm)	Time required (t) for 1 liter water collect in measuring flask (Sec)

CALCULATIONS:

Actual X-Coordinate in cm = (X-Coordinate in mm + X-Coordinate start point in mm)/10
Actual Y-Coordinate in cm = (Y-Coordinate in mm - Y-Coordinate start point in mm)/10

RESULT TABLE:

No. of Observation/Group No.	01	02	03	04	05	06
Actual X-Coordinate (cm)						
Actual Y-Coordinate (cm)						
Actual discharge Qa (cm^3/sec)						
Theoretical discharge Qt (cm^3/sec)						
Actual velocity V_a (cm/sec)						
Theoretical velocity V_t (cm/sec)						
Actual Head H (cm)						
Head loss H_L (cm)						
Coefficient of discharge Cd						
Coefficient of Velocity Cv						
Coefficient of contraction Cc						

Signature of the Teacher

NB: Use extra pages for calculation & Discussion.

ID: ……………………………………………

Group:……………………………………………

Section:……………………………………………

Performance Date:………………………….

North South University
Department of Civil and Environmental Engineering

CEE 211L FLUID MECHANICS LAB
WORKBOOKS FOR LABORATORY PRACTICE

EXPERIMENT NO: 04
FLOW THROUGH AN EXTERNAL MOUTHPIECE

Name:

ID:

Group:

Section:

Performance Date:

Submission Date:

EXPERIMENT NO: 04
FLOW THROUGH AN EXTERNAL MOUTHPIECE

Objective:

1. To determine the coefficient of discharge Cd for an external Mouthpiece.
2. To plot Q_a vs H in log-log paper and to find (a) the exponent of H and (b) C_d

General:

If a small tube is attached to an orifice, it is called mouthpiece. The standard length of a mouthpiece is 3d, where d is the diameter of the orifice. If the length is less than 3d, jet after passing the vena contracta does not does not occupy the tube fully and thus acts as orifice. If the length is greater than 3d, it acts as pipe.
The effect of adding a mouthpiece to an orifice is to increase the discharge. The pressure at a vena contracta is less than atmospheric, so a mouthpiece decreases the pressure at vena contracta and increases the effective head causing the flow, hence discharged is increased. The pressure at outlet is atmospheric but as the velocity of the vena contracta is greater than the velocity at outlet, the pressure at vena contracta will be less than atmospheric.

Practical application:

Flow through an orifice can't represent the flow through a pipe properly. Also an orifice, coefficient of discharge is only 0.62. So to increase discharge from a reservoir and represent the flow through pipe, mouthpiece is used.

Theory:

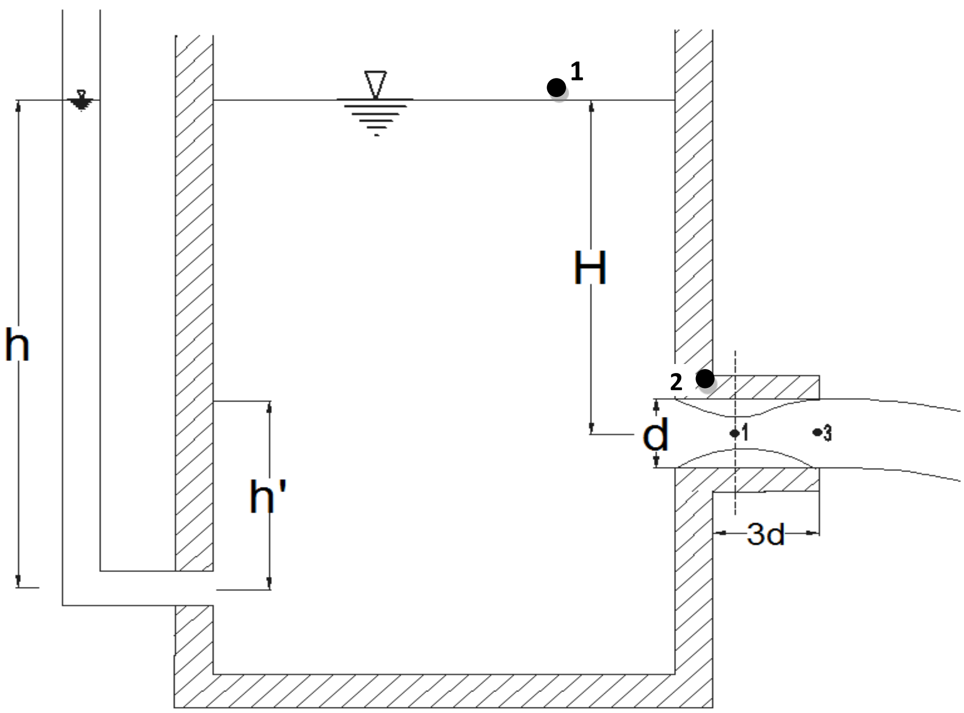

Figure: Flow through an external Mouthpiece

Considering an external cylindrical mouthpiece of area A discharging water under a constant head H as shown in figure. Applying Bernoulli's equation at point 1 and 3

$$H = \frac{V^2}{2g}$$

or, $V = \sqrt{2gH}$

Then the theoretical discharge Qt is given by,

$$Q_t = A\sqrt{2gH}$$

where A is the area of the mouthpiece.

Let Q_a be the actual discharge. Then,

Coefficient of discharge (C_d):

The ratio of actual rate of discharge to the theoretical rate of discharge (the flow that would occur if there were no friction and no contraction) is called coefficient of discharge.

$$C_d = \frac{Q_a}{Q_t}$$

Description of Apparatus:

This is a self-contained, compact, closed circuit set-up in hydraulics laboratory. It consist of a tank, mono-block pump and a measuring tank along with necessary piping.
A measuring flask (2 liter) is provided for flow measurement. After measuring the water discharge at specific time intervals, water in the measuring flask is released into measuring tank. Further all water released to sump tank by opening the valve2.

Specification:

- Mouthpiece : 1:1 & 4:1
- Measuring Flask: 2 Liters.

Procedure:

1. Fill the sump tank by sufficient water.
2. Place the required assembly and add the hose nipple to QRC.
3. Also attach the required mouthpiece. Loose the knobs to add the pointers and after then tight the knobs.
4. Now check the inlet VALVE1 in full clockwise direction.
5. Now press the MAINS button to ON position.
6. Allow the water to rise to any constant level. (For quick rise of water in the tank, the orifice may be closed by hands)
7. Deliver the overflow water into the drain directly by a PVC pipe connection. Adjust this pipe by hand to maintain the constant head over the centerline.
8. Wait for some time. After that Record 'h' i.e. head over the centerline of the orifice in mm.
9. Adjust the all pointed tip of the rod at the center of the jet to touch the water flowing through mouthpiece.
10. Measure all the Y-coordinates in mm with the steel scale from the center of the knob to the water touching line.
11. Also measure all the X-coordinates in mm each difference is 25mm.

12. Same process repeat for another mouthpiece.
13. To vary the head over the mouthpiece, raise or lower the overflow pipe.
14. During the experiment, ensure that the water overflows continuously through the pipe.

Practice Questions:

1. Explain why the discharge through an orifice is increased by fitting a standard short tube to it.
2. What will happen to the coefficient of discharge if the tube is shorter than the standard length or the head causing the flow is relatively high?
3. What is the effect of rounding the entrance of the mouthpiece?
4. What is a submerged tube? Does the coefficient of the tube change due to submergence?

EXPERIMENT NO: 04
Flow through an external Mouthpiece
Experimental Data and Calculation Sheet

OBSERVATIONS:

Diameter of the mouthpiece, d = **10 mm = 1.0cm**
Length of the mouthpiece, L = **35 mm = 3.5cm**
X-Coordinate start point = **48 mm**
Y-Coordinate start point = **50 mm**

OBSERVATION TABLE:

Sl. No.	Head (H) over the center line (cm)	Time required (t) for 1 liter water collect in measuring flask (Sec)

RESULT TABLE:

No. of Observation/ Group No.	1	2	3	4	5	6	7
Actual discharge Qa (cm^3/sec)							
Theoretical discharge Qt(cm^3/sec)							
Actual Head H (cm)							
Coefficient of discharge Cd							

ID: ....

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NB: Use extra pages for calculation & Discussion.

North South University
Department of Civil and Environmental Engineering

CEE 211L FLUID MECHANICS LAB
WORKBOOKS FOR LABORATORY PRACTICE

EXPERIMENT NO: 05
FLUID FRICTION IN A PIPE

Name:

ID:

Group:

Section:

Performance Date:

Submission Date:

EXPERIMENT NO: 05
FLUID FRICTION IN A PIPE

Objective:

1. Determination of coefficient of friction for pipes of different materials.
2. To plot h_L vs Velocity in log-log paper and determine the empirical relationship of the form $h_L = KV^n$
3. To plot f R_e in log-log paper and find the empirical relation of the form $f = C R_e^m$

General:

Head loss in a pipe flow is mainly due to friction in pipes and again friction is due to roughness of pipes. It has been proved that friction is dependent not only upon the size and shape of the projection of roughness, but also upon their distribution or spacing.

Practical application:

In designing a pipe network, we may need minimum heads at different points of the network. For attaining the minimum head we need to know the head loss from source of the point of interest due to the friction along the pipe. This experiment gives an estimate of head loss due to friction in the pipe per unit length of the pipe.

Theory:

If the head loss in a given length of uniform pipe is measured at different values of the velocity, it will be found that, as long as the velocity is low enough to secure laminar flow, the head loss due to friction, will be directly proportional to the velocity. But with the increasing velocity, at some point where the visual observation in a transparent tube would show that the flow changes from laminar to turbulent, there will be an abrupt increase in the rate at which the head loss varies. If the logarithms of those two variables are plotted on linear scales or if the values are plotted directly on log-log paper, it will be found that, after a certain transition region has been passed, lines will be obtained with slopes ranging from about 1.75 to 2.00.

It is thus understood that for laminar flow the drop in energy due to friction varies as V, while for turbulent flow the friction varies as V^n, where n ranges about 1.75 to 2.00. The lower value of 1.75 for turbulent flow is found for pipes with very smooth walls, as the roughness increase the value of n increases up to a value 2.00.

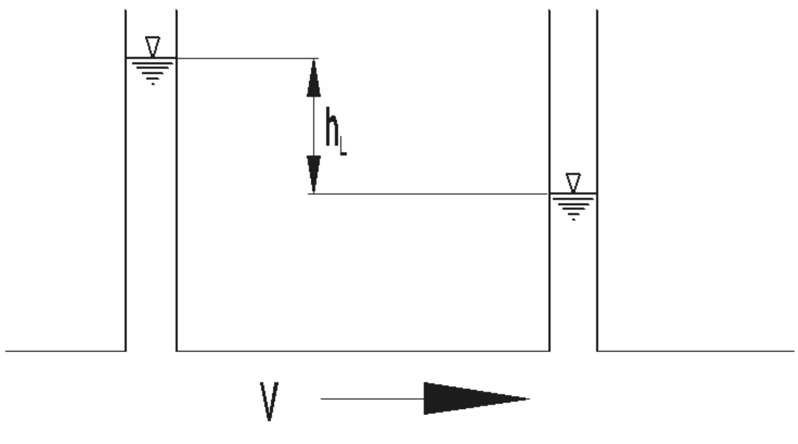

Fig: Head loss due to friction in pipe

However, velocity is not the only factor that determines whether the flow is laminar or turbulent. The criterion is Reynolds number. For a circular pipe the significant linear dimension L, is usually taken as the diameter D, and thus

$$R_e = \frac{VD}{\nu}$$

Head loss hl can be generalized with velocity, V by

$h_L \propto V^n$

Where n is the exponent of velocity.

Therefore, $h_L = KV^n$, where K is a constant.

The flow of water in long, straight, uniform circular pipes indicated that head loss (h_L) varies directly with velocity head($\frac{V^2}{2g}$) and pipe length (L) and inversely with pipe diameter (d).

$$h_L = \frac{4f\ x\ L\ x\ V^2}{d\ x\ 2g}$$ Where f =friction factor

$$\text{or, } \boldsymbol{f = \frac{2g\ x\ d}{L\ x\ V^2}}\ h_L \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

$$= \varphi(R_e) = 0.079Re^{-0.25}$$

Friction factor also depends upon the relative roughness.

For laminar flow head loss (h_L) given by Hagen-Poiseuille is

$$h_L = \frac{32\mu LV}{\rho g d^2}$$

$$\textbf{as, } \boldsymbol{f = \frac{64}{Re}}$$

Therefore friction factor (f) can be related empirically as,

$$f = \varphi(R_e) = C\ R_e^m$$

Where n is the exponent of Reynolds number and C is a constant.

The striking feature of the equation is that it involves no empirical coefficient or experimental factors of any kind, except for the physical properties of fluid such as, viscosity and density. From this it would appear that in laminar flow the friction is independent of the roughness of the pipe wall.

Description of Apparatus:

- This is a self- contained, compact, closed circuit set-up in hydraulics laboratory. It consist of a tank, mono-block pump and a measuring tank along with necessary piping. Watger is delivered to the set-up by a motorized pump set through a control valve and a measuring tank for flow measurement.
- The pipe friction apparatus has been designed to work on the close circuit set-up. It consist of four pipes of different materials, taken out from a common inlet connection and is provided with control valves to regulate the flow, near the downstream of the end of the pipe. Pressure toppings (2nos) are provided at suitable distance apart, between which a common pressure gauge is provided.

Specification:

Types of pipes

- GI : Ø16 mm ID x 1000 mm length.
- Cu : Ø16 mm ID x 1000 mm length.
- Al : Ø16 mm ID x 1000 mm length.
- Ms : Ø16.3 mm ID x 1000 mm length.

Procedure:

1. Fill the sump tank by sufficient water.
2. Place the required assembly and add the hose nipple to QRC.
3. Now check the inlet VALVE1 in full clockwise direction.
4. Open the entire bypass valve of all pipes.
5. Now press the MAINS button to ON position.
6. Now open only bypass valve of pipe we have to calculate coefficient of friction and close all the other three bypass valves of remaining pipes. (For example we have to fined coefficient of friction for GI pipe then open only bypass valve of GI pipe)
7. Also close all small ball valves of manifold. Only open for which pipe we have to find coefficient of friction. (Example: For GI pipe is – GIP1 & GIP2)
8. Now also connect the pipes from P1 and P2 of manifold to P1 & P2 of pressure gauge manifold. Also all three small ball valves of pressure gauge manifold are closed.
9. Give some back pressure with the help of closing the bypass valve of Venturimeter pipe slowly.
10. Open ball valves for P1 and DRAIN. Close the DRAIN. Note down the value of P1 in PSI. Close P1. Open P2 and DRAIN. Close ball valve DRAIN and note down the value of P2 in psi.
11. Same time close the VALVE2 for measuring the water level
12. Keep stopwatch in hand and take the time intervals for 5 liter water level height. Better when water reaches to 15 liter mark start the stopwatch and when reach the 20 liter mark stop the stopwatch and open the VALVE2.
13. Change the discharge through GI pipe by operating bypass valve and repeat the above procedure to obtain different observations.
14. Same process repeat for different pipes.

Practice Questions:

1. What are the factors upon which the frictional loss in pipe depends?
2. What is meant by critical Reynolds number?
3. Write down the different types of losses that may occur in pipe flow.

EXPERIMENT NO: 05
Fluid Friction in a pipe
Experimental Data and Calculation Sheet

OBSERVATIONS:

Actual Length of pipe L = 1000 mm = 100cm
Diameter of Cu. pipe = 16 mm = 1.6 cm
Diameter of GI. pipe = 16.2mm = 1.62 cm
1 psi = (10.19744316 X 0.0689476) = 0.7031 mtr of water.

Diameter of Al. pipe = 16 mm = 1.6 cm
Diameter of MS. pipe = 16.3 mm = 1.63 cm

OBSERVATION AND RESULT TABLE:

Type of pipe	Sl. No.	P1 (Psi)	P2 (Psi)	Time required (t) for 5 liter raise in water level (Sec	h_L = (P1-P2)x70.31 (cm)	Discharge Qa (cm^3/sec)	Area of Pipe A (cm^2)	Velocity V=Qa/A (cm/sec)	Coefficient of friction f	Reynolds Number Re

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Signature of the Teacher

NB: Use extra pages for calculation & Discussion.

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North South University
Department of Civil and Environmental Engineering

CEE 211L FLUID MECHANICS LAB
WORKBOOKS FOR LABORATORY PRACTICE

EXPERIMENT NO: 06
FLOW OVER A V-NOTCH

Name:

ID:

Group:

Section:

Performance Date:

Submission Date:

EXPERIMENT NO: 06
FLOW OVER A V-NOTCH

Objective:

1. To determine the coefficient of discharge Cd, for the V-notch.
2. To plot Q_t vs Q_a in a plain graph paper.
3. To plot Q_a vs H in log-log paper and to find (a) the exponent of H and (b) C_d

General:

The triangular or V-notch weir is preferable to the rectangular weir for the measurement of widely variable flows. In the case of a rectangular weir the total wetted perimeter does not vary directly with the head, as the length of the base is the same for all heads. Therefore the coefficient of contraction, which depends on the wetted perimeter, is not constant for all heads. But in case of a V-notch, there is no base to cause contraction, which will be due to the sides only. The coefficient of contraction wii, therefore, be a constant for all heads. For this reason, the V- notch is the most satisfactory type for flow measurement in canals.

Practical application:

The V-notch weir is preferred when small discharges are involved, because the triangular cross section of the flow 'nappe' leads to a relatively greater variation in head. V-notch weir has the advantage that it can function for a very small flows and also measure reasonably larger flows as well.

Description of Apparatus:

This is a self- contained, compact, closed circuit set-up in hydraulics laboratory. It consists of a tank, mono-block pump and a measuring tank along with necessary piping.

The apparatus consists of a channel (Notch duct = 1110mm X 170mm X 360mm). The supply to the channel is taken from bottom/side at one end of the channel. At the other end required notch plate is fitted. Upstream from the face of notch, a well is provided.

Theory:

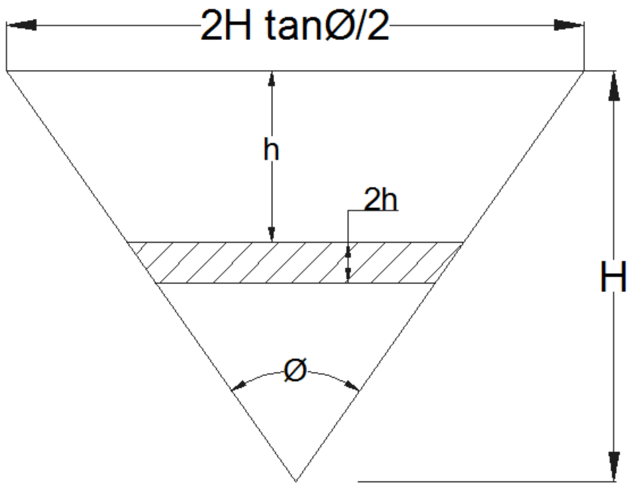

Fig: Flow through a V-Notch

Considering the V-Notch shown in figure, let H be the height of water surface and θ be the angle of notch. Then width of the notch at the water surface

$L = 2H\, tan\frac{\theta}{2}$ ………………………………………………………………………… (1)

Consider a horizontal strip of the notch of thickness dh under a head h. Then, width of the strip,

$W = 2(H-h)\, tan\frac{\theta}{2}$ ……………………………………………………………………. (2)

Hence, the theoretical discharge through the strip,

$dQ_t = Area\ of\ the\ strip\ x\ Velocity = 2(H-h)\tan\frac{\theta}{2} dh\sqrt{2gh}$ ……………………….. (3)

Integrating between the limits 0 to H and simplifying, the total theoretical discharge over the notch is given by,

$Q_t = \frac{8}{15}\sqrt{2g}\ \tan\frac{\theta}{2}\ H^{5/2}$ ………………………………………………………………… . (4)

Or, $Q_t = K\, H^{5/2}$ ……………………………………………………………………………(5)

Where, $K = \frac{8}{15}\sqrt{2g}\ \tan\frac{\theta}{2}$ ………………………………………………………….(6)

Let Qa be the actual discharge. Then the

Coefficient of discharge (C_d):

The ratio of actual rate of discharge to the theoretical rate of discharge (the flow that would occur if there were no friction and no contraction) is called coefficient of discharge.

$C_d = \frac{Q_a}{Q_t}$ ……………………………………………………………………..(7)

Or, $Q_a = K\, C_d H^{5/2}$ ……………………………………………………………….(8)

The coefficient of discharge depends on relative head (H/P), relative height (P/B), and angle of the notch (θ)

From hydraulic point of view a weir may be fully contracted at low heads while at increasing head it becomes partially contracted. The flow regime in a weir is said to be partially contracted when the contractions along the sides of the V-notch are not fully developed due to proximity of the walls or bed of approach channel. Whereas a weir which has an approach channel and whose bed and sides of the notch are sufficiently remote from the edges of the V-notch to allow for a sufficiently great approach velocity component parallel to the weir face so that the contraction is fully developed is a fully contracted weir. In case of a fully contracted weir Cd is fairly constant for a particular angle of notch.

At lower heads, the frictional effects reduce coefficients. For the most common angle of notch 90 degree, the discharge coefficient Cd is about 0.6.

Procedure:

1. Fill the sump tank by sufficient water.
2. Place the required notch.
3. Set the digital gauge pointer to touch the notch duct. Set it to zero by pressing the zero button on digital depth gauge.
4. Now set the pointer to up position. The values are in (–ve)
5. Now add the hose nipple to QRC.
6. Now check the inlet VALVE1 in full clockwise direction.
7. Now press the MAINS button to ON position.

8. Open the inlet valve and let water into the channel.
9. When the water level comes up to the sill of the notch, stop the inflow and note the sill level reading.
10. Again start inflow into the channel. The water level in the channel will slowly rise. After some time, when inflow into the channel is equal to outflow, the water level into the channel will remain steady. Note down this level of water, the difference between the readings will give head over the notch.
11. Allow the water to flow over the notch for a suitable time and measure the discharge by measuring tank.
12. By changing head over the notch, a few readings are recorded.

Practice Questions:

1. Why does the V-notch give more accurate flow measurement the any other weirs and orifices when is slightly fluctuating?
2. What is the value of Cd for 45 degree V-notch? Does it depends on flow condition (partially or fully contracted)?
3. Determine the discharge of water over a 60 degree triangular weir if the measured head is 0.623ft.

EXPERIMENT NO: 06
Flow over a V-notch
Experimental Data and Calculation Sheet

OBSERVATIONS:

Sill level reading, S = 27.5 mm
Angle of V-notch, Ø = 45^0

OBSERVATION AND RESULT TABLE:

Sl. No.	Hook(Depth) gauge reading R (cm)	Time required (t) for 5 liter raise in water level (Sec)	Effective head H= (R-S) (cm)	Actual discharge Q_a (cm^3/sec)	Theoretical discharge Q_t (cm^3/sec)	Coefficient of discharge C_d

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Signature of the Teacher

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North South University
Department of Civil and Environmental Engineering

CEE 211L FLUID MECHANICS LAB
WORKBOOKS FOR LABORATORY PRACTICE

EXPERIMENT NO: 07
CENTER OF PRESSURE

Name:

ID:

Group:

Section:

Performance Date:

Submission Date:

EXPERIMENT NO: 07
CENTER OF PRESSURE

Objective:

1. To determine the distance of centre of pressure from the water surface both theoretically and practically.
2. To plot the mass on the pan (M) against y_2 in plain graph paper

General:

The centre of pressure is a point on the immersed surface at which the resultant of liquid pressure forces acts. In case of horizontal area the pressure is uniform and the resultant pressure force passes through the centroid of the area. In an inclined surface, this point lies towards the deeper end of the surface as the intensity of pressure increases with depth. The objective of this experiment is to locate centre of pressure of an immersed rectangular surface and to compare this position with that predicted by theory.

Practical application:

In designing a hydraulic structure (e.g a dam) we need to know the overturning moment about toe O created by water pressure on the structure. In this case $M_o = F \times d$, where F is the force on the dam and d is the distance of the centre of pressure from the bottom.

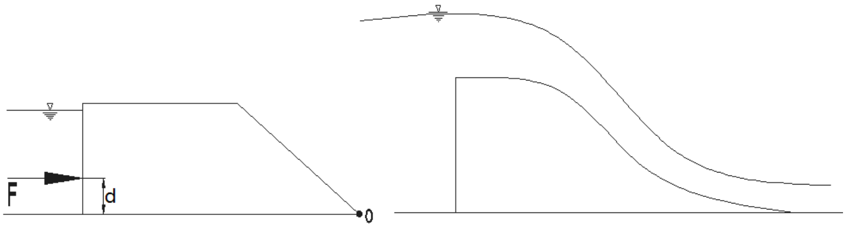

Fig-1: Practical application of Centre of Pressure

Theory:

The magnitude of the total hydrostatic force F will be given by

$$F = \rho g \bar{y} A$$

Where,

$\rho =$ density of fluid

g = acceleration due to gravity

$\bar{y}$ = depth of centroid of immersed surface

A = Area of immersed surface

This force will act through the centre of pressure C.P at a distance y_p (measured vertically) from point O, where o is the intersection of the plane of the water surface and the plane of the rectangular surface.

Theoretical determination of y_p:

$$y_p = \bar{y} + \frac{I_{CG}}{Ay} \quad \text{...(1)}$$

Where, $\bar{y}$ =distance from 0 to the centroid CG of the immersed surface.

$I_{CG} = 2^{nd}$ moment of area of the immersed surface about the horizontal axis through CG.

Experimental determination of yp:

For equilibrium experimental apparatus, moments about the pivot P give

F.y =W.Z = MgZ ……………………………………………………..(2)

Where, y = distance from pivot to centre of pressure

M = mass added to hanger

Z = distance from pivot to hanger

Therefore, from equation (2)

$$y = \frac{MgZ}{F}$$

But,

$y = y_p + r - y_1$ (Fully submerged)

$y = y_p + r + y_1$ (Partially submerged)

Therefore,

$y_p = y - (r - y_1)$ (Fully submerged)

$y_p = y - (r + y_1)$ (Partially submerged)

Where

r = distance from pivot to top of rectangular surface

y_1= depth of water surface from top of rectangular surface

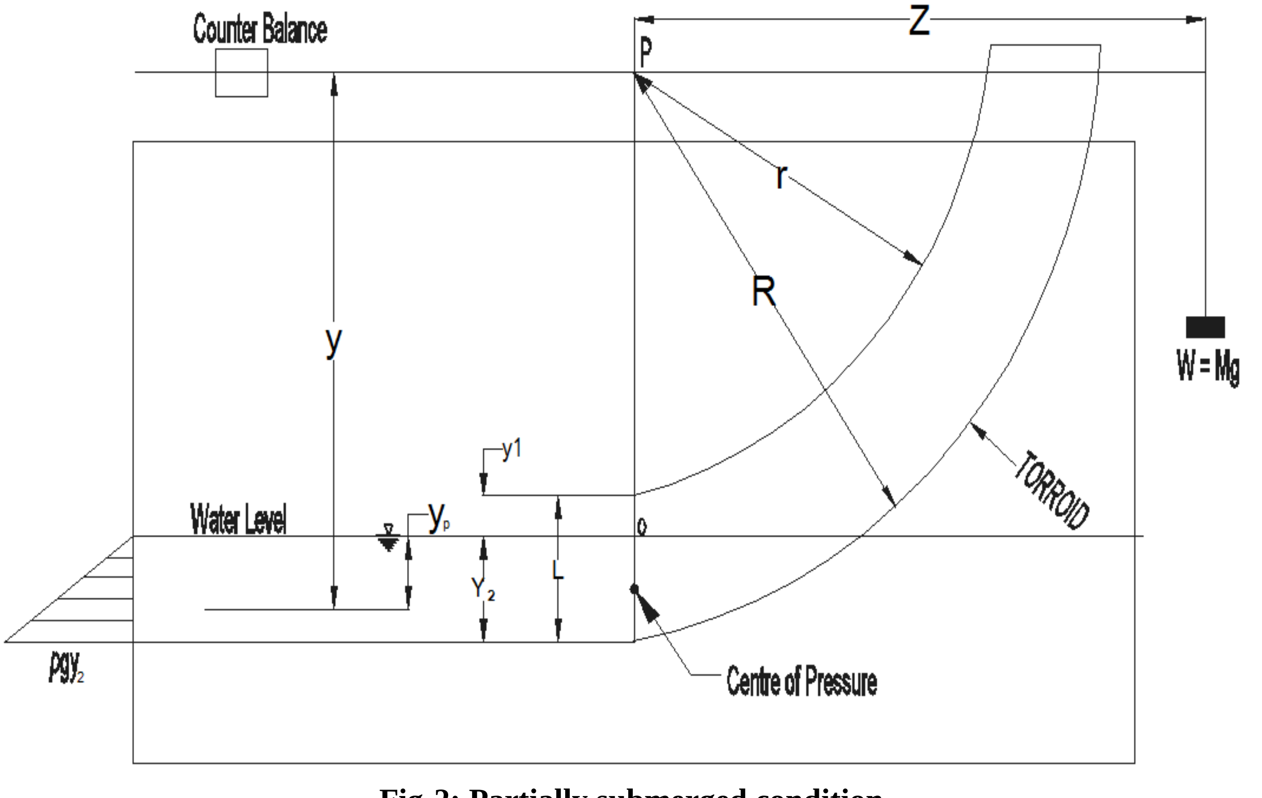

Fig-2: Partially submerged condition

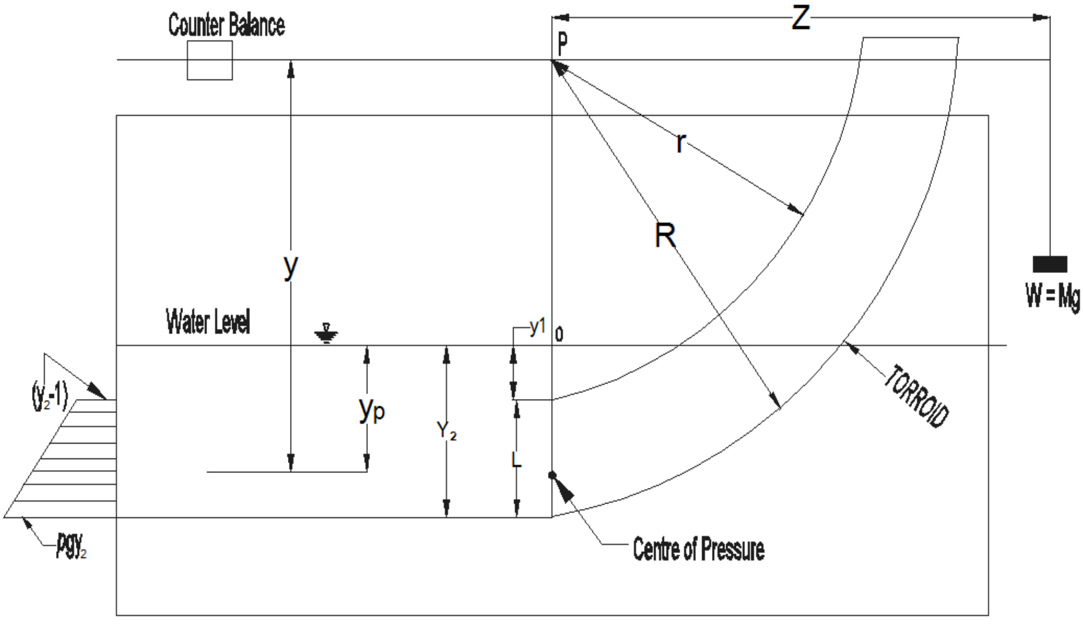

Fig-3: Fully submerged condition

Procedure:

1. The apparatus is placed in a splash tray and correctly leveled.
2. The length l and width b of the rectangular surface, the distance r from the pivot to the top of the surface, and the distance s from the hanger to the pivot are recorded.
3. The rectangular surface is positioned with the face vertical (θ =0) and clamped.
4. The position of the moveable jockey weight is adjusted to give equilibrium, i.e. when the balance pin is removed there is no movement of the apparatus. The balance pin is replaced.
5. Water is added to the storage chamber. This created an out of balance clockwise moment in the apparatus. A mass M is added to the hanger and water is slowly removed from the chamber via drain hole such that the system is brought almost to equilibrium, but now clockwise moment is marginally greater. Water is slowly added to the storage chamber by a dropper until equilibrium is attained. At this condition the drain hole is closed and balance pin again removed to check equilibrium.
6. The balance pin is replaced and the values of y_1 , y_2 and M are recorded.
7. The above procedure is repeated for various combinations of depth.

Practice Questions:

1. Discuss why the centre of pressure is below the centre of gravity for an inclined surface.
2. What are the practical applications of the centre of pressure?
3. If a triangle of height d and base b is vertical and submerged in liquid, drive an expression for the depth to its centre of pressure from the liquid surface.

EXPERIMENT NO: 07
Centre of Pressure
Experimental Data and Calculation Sheet

OBSERVATIONS DATA:

Inner radius of curvature, r =
Outer radius of curvature, R =
Width of plane surface, B =
Height of plane surface, L =
Distance from pivot to hanger, Z =

OBSERVATION AND CALCULATION TABLE:

Sl. No./Gr. No.	y_1	y_2	Weight on pan	$\bar{y}$	F	I_{CG}	$\frac{I_{CG}}{\bar{y}\,A}$	y_p Theoretical	M	y_p Experimental	Submerged Condition Partially/fully

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Signature of the Teacher

NB: Use extra pages for calculation & Discussion.

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North South University
Department of Civil and Environmental Engineering

CEE 211L FLUID MECHANICS LAB
WORKBOOKS FOR LABORATORY PRACTICE

EXPERIMENT NO: 08
FLOW OVER A SHARP-CRESTED RECTANGULAR WEIR

Name:

ID:

Group:

Section:

Performance Date:

Submission Date:

EXPERIMENT NO: 08
FLOW OVER A SHARP-CRESTED RECTANGULAR WEIR

Objective:

1. Observation of the nappe for ventilated and non-ventilated conditions.
2. To find C_d for the weir
3. To plot Q_a vs. H in a plain graph paper.
4. To plot Q_a vs. H in a log-log graph paper and to find (1) the exponent of H and (2) C_d

General:

A weir is an overflow structure built across an open channel for the purpose of measuring the flow. Weirs are commonly used to measure flow of water, but their use in measurement of other liquids is increasing.

Classified with reference to the shape of the opening through which the liquid flows, weirs may be rectangular, triangular, trapezoidal, circular, parabolic or of any other regular form. The first three forms are most commonly used for measurement of water. Classified with reference to the form of crest (the edge or the top surface with which liquid comes in contact) weirs may be sharp-crested or broad-crested. The sharp-crested rectangular weir has a sharp upstream edge so formed that the liquid in passing touches only a line.

The over falling stream is termed as 'nappe'. The nappe of a sharp crested weir as shown in fig is contracted at its underside by the action of the vertical components of the velocity just upstream from the weir. This is called crest contraction. If the sides of the opening also have sharp upstream edge so that the nappe is contracted in width, the weir is said to have end contractions and is usually called a contracted weir.

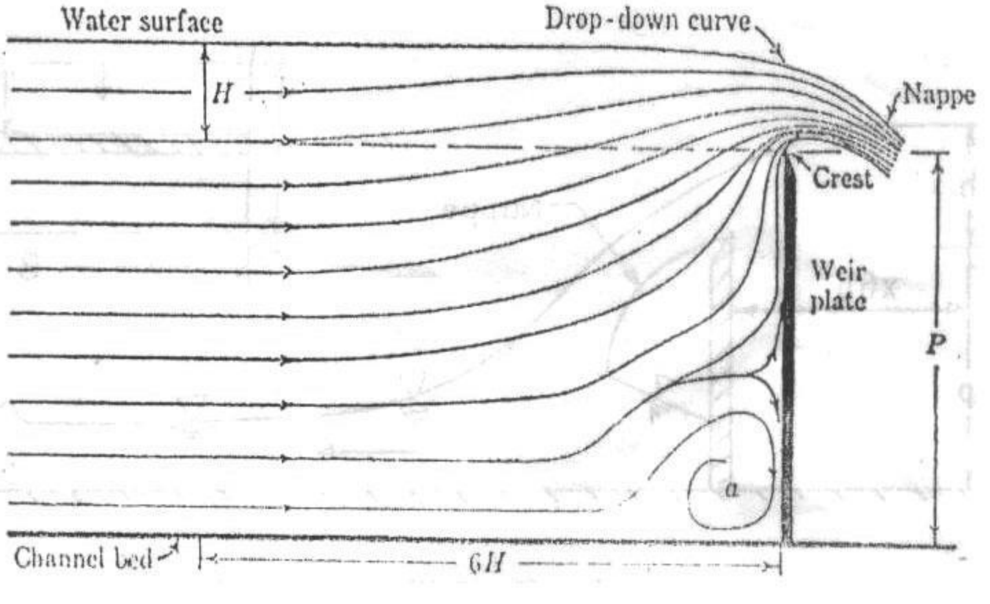

Fig 1 Path lines of flow over rectangular sharp-crested weir

Practical application:

Shallow rivers are often navigable by building dams across the river at certain sections over which the water may flow. During a drought little or no water will flow past the dam, but after heavy rains the water flows over the dam, thus converting it into a weir. Also flow through canal is measured by weirs.

Theory:

The relationship between discharge and head over the weir can be developed by making the following assumptions as to the flow behavior:

1. Upstream of the weir, the flow is uniform and the pressure varies with depth according to the hydrostatic equation $P = \gamma h$
2. The free surface remains horizontal as far as the plane of the weir, and all particles passing over the weir move horizontally. (In fact, the free surface drops as it approaches the weir).
3. The pressure throughout the sheet of liquid or nappe, which passes over the crest of the weir, is atmospheric.
4. The effects of viscosity and surface tension are negligible.
5. The upstream approach velocity head is neglected.

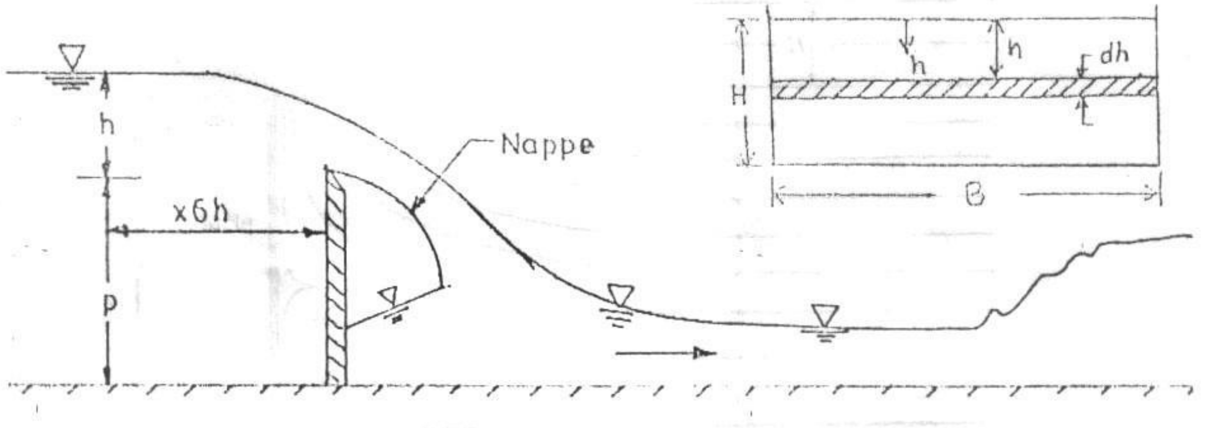

Fig. 2 Flow Over a Sharp-Crested weir

Now consider the sharp-crested weir in the figure. Let H be the working head and B is the length of the weir.

Let us consider a small horizontal string of thickness dh under a head h. The strip can be considered as an orifice.

Therefore, the theoretical discharge through the strip

dQ1=area of the strip x velocity (1)

$dQ1 = Bdh\sqrt{2gh}$ ……………………………………………………………………(2)

Integrating between the limits 0 and H, the total theoretical discharge over the weir is given by

$Q_t = \frac{2}{3} B\sqrt{2g}\ H^{3/2}$ ……………………………………………………………………(3)

Let Q_a be the actual discharge. Then the co-efficient of discharge, C_d is given by

$$C_d = \frac{Q_a}{Q_t} \quad \text{………………………………………………………………………………………(4)}$$

Therefore,

$$Q_a = \frac{2}{3} C_d \sqrt{2g}\ B\, H^{3/2} \quad \text{…………………………………………………………………(5)}$$
$$= K\, C_d\, H^{3/2} \quad \text{……………………………………………………………………………(6)}$$

Where,

$$K = \frac{2}{3} \sqrt{2g}\, B \quad \text{………………………………………………………………………………(7)}$$

For a contracted weir, B is in equation (5) should be replaced by effective length B' which is given by

$B' = B - 0.1nH$

Where n is the number of end contraction.

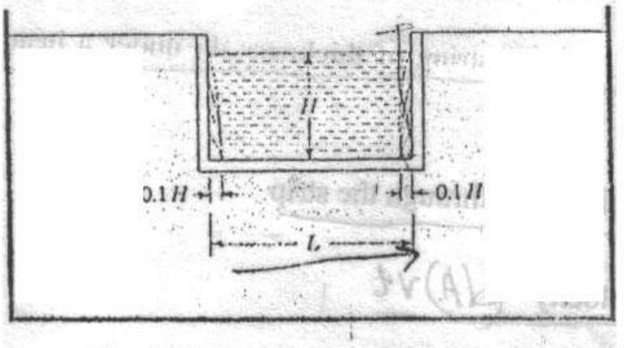

Fig 3 Weir with end contractions

Procedure:

1. Measure the height and Width/Length of the weir. Position the weir plate at end side of the approach channel, in a vertical plane, with sharp edge on the upstream side.

2. Allow water to the channel so that water flows over the weir and wait until water surface comes to a steady condition.

3. Ventilate the nappe with a pipe.

4. Set an elevation of zero of the point gauge with reference to the bottom of the channel.

5. Check again whether the nappe is ventilated or not. If not, ventilate it.

6. Carefully set the point gauge on the water surface 4 to 6ft upstream of the weir and take the gauge reading. The water surface may be slightly fluctuating.

7. Take the discharge reading from the flow meter.

Practice Questions:

1. What are the assumptions made in deriving this equation? What is the extent of their validity?

2. Why the pressure distribution over the weir-crest is less than hydrostatic?

3. Why it is necessary to ventilate the space below the nappe?

4. Discuss the effects of lateral contraction, in case of contracted weir, on the flow over the weir

5. A rectangular sharp crested weir 3.0 ft high extends across a rectangular channel, which is 8.0 ft wide. When the head is 1.20 ft, find the rate of discharge by neglecting the velocity of approach.

Experiment No. 08
Flow over a Sharp-Crested Rectangular Weir
Experimental Data and Calculation Sheet

OBSERVATIONS:

Cross Section of End tank = (77.8 X 60.3) cm^2

Rotameter Reading Qa_1 = LPM (LPM = Litter per minutes)

Width of the weir, B = 300mm = 30cm

Depth of the weir, $\mathbf{H_1}$ = 150mm = 15cm

Water Level in upstream, $\mathbf{h_1}$ =

$\mathbf{h_2}$ =

$\mathbf{h_3}$ =

Actual discharge from end tank, $\mathbf{Q_{a2}} = \frac{\text{(Cross Section of end tank X Water Rise in tank)}}{\text{Time}}$

OBSERVATION AND RESULT TABLE:

Sl. No.	Water Level in upstream $\mathbf{H_2} = (\frac{\mathbf{h1+h2+h3}}{\mathbf{3}})$ cm	Head Over the Weir H=($\mathbf{H_2}$-$\mathbf{H_1}$) (cm)	Time(t) for 100 mm Rise in End Tank (Sec)	Actual discharge $\mathbf{Q_a} = (\frac{\mathbf{Q_{a1}+Q_{a2}}}{\mathbf{2}})$ (cm^3/sec)	Theoretical discharge $\boldsymbol{Q_t}$ (cm^3/sec)	Coefficient of discharge $\boldsymbol{C_d}$

ID: ……………………………………..

Group:…………………………………

Section:…………………………………

Performance Date:……………………

Signature of the Teacher