CHENDU COLLEGE OF ENGINEERING & TECHNOLOGY

CE 2258 APPLIED HYDRAULIC ENGINEERING LABORATORY

DEPARTMENT OF CIVIL ENGINEERING

SECOND YEAR CIVIL

(As per ANNA UNIVERSITY Syllabus)

LABORATORY MANUAL

LIST OF EXPERIMENTS

1. DETERMINATION OF COEFFICIENT OF DISCHARGE OF A VENTURIMETER

AIM:

To determine the coefficient of discharge (C_d) of a venturimeter and to plot the following graphs:

1. $\sqrt{H}$ Vs Q_a And 2. H Vs Q_a

APPARATUS REQUIRED:

1. Pipe line setup with venturimeter fitted in the pipe line.
2. A manometer to measure the pressure drop between the entrance and throat of the venturimeter.
3. A tank to collect water.
4. A stop watch.

THEORY:

Venturimeter is a device used to measure the flow through a pipe line. The pressure difference between the inlet and throat of the venturimeter is measured by using a differential U – tube manometer. The time taken to collect a fixed quantity of the liquid is noted. The theoretical discharge and actual discharge are calculated, from which the coefficient of discharge of the venturimeter can be calculated.

FORMULAE USED:

Coefficient of discharge, C_d = (Q_a / Q_t)

Theoretical discharge, Q_t = $\sqrt{2gH} \times \dfrac{a_1 \times a_2}{\sqrt{(a_1)^2 - (a_2)^2}}$

Actual discharge, Q_a = $(l \times b \times h) / t$

g – Acceleration due to gravity = 9.81 m/s^2

H - Equivalent column of water = $(h_1 - h_2)\left(\dfrac{s_m - s_l}{s_l}\right)$ in 'm'

a_1 - Area of the pipe (m^2) a_2 - Area of the throat (m^2)

l – Length of the tank (m) b – Breadth of tank (m)

h – Height of liquid collection (m) t – time for collection (sec)

h_1, h_2 – Deflection in manometer s_m, s_l – Sp. Gravity of manometer and flowing fluid respectively

PROCEDURE:

1. Check up the experimental setup.
2. Measure the length (l) and breadth (b) of the tank.
3. Note the diameter of the pipe line (d_1) and throat diameter (d_2).
4. Ensure water flow in the pipe line.
5. Open the flow control valve to maximum. Ensure that the mercury levels in the manometer are steady.
6. Allow water to flow for some time.
7. Note the deflections in the manometer (h_1, h_2).
8. Close the tank outlet valve.
9. Note the time ('t' sec) to collect 'h' m height of water in the tank.
10. Open the tank outlet valve.
11. Close the flow control valve slightly and repeat steps 7 to 10.
12. Tabulate the observations.

OBSERVATIONS AND TABULATIONS:

Length of tank, l = ………. (m)

Breadth of tank, b = ………. (m)

Height of collection, h = 0.1 m

Diameter of the pipe, d_1 = ……….. (m)

Diameter of throat, d_2 = ……….. (m)

Specific gravity of manometric fluid (Mercury), s_m = 13.6

Specific gravity of flowing fluid (Water), s_l = 1.0

Sl. No.	Deflection in manometer			H (m)	$\sqrt{H}$	Time 't' (sec)	Q_a (m^3/s)	Q_t (m^3/s)	C_d
	h_1 (cm)	h_2 (cm)	$h_1 - h_2$ (cm)						
1									
2									
3									
4									
5									

MODEL CALCULATION:

Area of cross section of the tank, A = l X b = …….. X ……...

= …………… (m^2)

Actual discharge, Q_a = (A h) / t

= ………………………….. (m^3 / s)

Area of the pipe, a_1 = $\frac{\pi}{4} \times (d_1)^2$ = ………………………….

= ……………….. (m^2)

Area of the Throat, a_2 = $\frac{\pi}{4} \times (d_2)^2$ = ………………………….

= ……………….. (m^2)

Equivalent column of water, H = $(h_1 - h_2)\left(\frac{s_m - s_l}{s_l}\right)$ in 'm'

Theoretical discharge, Q_t = $\sqrt{2gH} \times \frac{a_1 \times a_2}{\sqrt{(a_1)^2 - (a_2)^2}}$

= ………………………….. (m^3 / s)

Coefficient of discharge, C_d = (Q_a / Q_t)

= …………………..

GRAPHS:

Draw the following graphs:

$\sqrt{H}$ Vs Q_a and

H Vs Q_a

From the graph, the value of $\sqrt{H}$ and Q_a between any two points are found out. Using these values C_d is calculated and compared with the average value of C_d found out by calculation.

RESULT:

Average value of C_d (from calculation) =

Value of C_d (from graph) =

2.DETERMINATION OF COEFFICIENT OF FRICTION OF A PIPELINE

AIM:

To determine the Darcy’s coefficient of friction (f) of a pipeline

APPARATUS REQUIRED:

5. Pipe line setup.
6. A manometer to measure the pressure drop between the gauging points at known distance.
7. A tank to collect water.
8. A stop watch.

THEORY:

The frictional resistance offered by a pipeline depends on the roughness of the surface of the pipeline carrying the flow. In laminar flow this frictional resistance is mostly due to viscous resistance of fluid to flow. In turbulent flow it is due to resistance offered by viscosity of fluid and surface roughness of the pipeline.

Frictional resistance varies:

1. With the degree of roughness of the surface of the pipeline in which the fluid flows
2. With the area of the surface coming in contact with the fluid
3. Directly as the velocity in laminar flow
4. Directly as the square of the velocity in turbulent flow
5. Directly as the density of the fluid and
6. Inversely as the viscosity of the fluid

The frictional resistance causes a loss of head (h_f)

FORMULAE USED:

Head loss due to friction, $h_f = \dfrac{4\,f\,L\,v^2}{2\,g\,D}$

f – Darcy's coefficient of friction

L – Length of pipeline between gauge points

v – Velocity of flow in the pipeline

g – Acceleration due to gravity = 9.81 m/s^2

PROCEDURE:

13. Check up the experimental setup.
14. Measure the length (L) of the pipeline between the gauge points.
15. Note the diameter of the pipe line (D).
16. Ensure water flow in the pipe line.
17. Open the flow control valve to maximum. Ensure that the mercury levels in the manometer are steady.
18. Allow water to flow for some time. Ensure that there are no air bubbles in the manometer
19. Note the deflections in the manometer (h_1, h_2).
20. Close the tank outlet valve.
21. Note the time ('t' sec) to collect 'h' m height of water in the tank.
22. Open the tank outlet valve.
23. Close the flow control valve slightly and repeat steps 7 to 10.
24. Tabulate the observations.

OBSERVATIONS AND TABULATIONS:

Length of tank, l = ………. (m)

Breadth of tank, b = ………. (m)

Length of pipe between pressure tapping, L = ………. (m)

Height of collection, h = 0.1 m

Diameter of the pipe, D = ……….. (m)

Specific gravity of manometric fluid (Mercury), s_m = 13.6

Specific gravity of flowing fluid (Water), s_m = 1.0

Sl. No.	Deflection in manometer			h_f (m)	Time 't' (scc)	Q (m^3/s)	V (m/s)	V^2 (m/s)	f
	h_1 (cm)	h_2 (cm)	$h_1 - h_2$ (cm)						
1									
2									
3									
4									
5									

MODEL CALCULATION:

Area of cross section of the tank, A = l X b = …….. X ……...

= …………… (m^2)

Discharge through pipeline, Q = (A h) / t

= ………………………….. (m^3 / s)

Area of the pipe, a = $\frac{\pi}{4} \times (D)^2$ = ………………………….

= ………………. (m^2)

Velocity of flow, v = Q / a = ………… / ……….. = ………… m/s

Head loss due to friction, h_f = $((h_1 - h_2)\left(\frac{s_m - s_l}{s_l}\right)$

Darcy's Coefficient of friction, f = $\frac{2\,g\,D\,h_f}{4\,L\,v^2}$

GRAPHS:

Draw the following graph: v^2 Vs h_f

RESULT:

Average value of Darcy's coefficient of friction, f =

3. DETERMINATION OF COEFFICIENT OF DISCHARGE OF AN ORIFICE METER

AIM:

To determine the coefficient of discharge (Cd) of a orifice meter and to plot the following graphs:

2. $\sqrt{H}$ Vs Q_a And 2. H Vs Q_a

APPARATUS REQUIRED:

9. Pipe line setup with orifice meter fitted in the pipe line.
10. A manometer to measure the pressure drop between the entrance and throat of the orifice meter.
11. A tank to collect water.
12. A stop watch.

THEORY:

Orifice meter is a device used to measure the flow through a pipe line. The pressure difference between the upstream and downstream side of the orifice meter is measured by using a differential U – tube manometer. The time taken to collect a fixed quantity of the liquid is noted. The theoretical discharge and actual discharge are calculated, from which the coefficient of discharge of the orifice meter can be calculated.

FORMULAE USED:

Coefficient of discharge, C_d = (Q_a / Q_t)

Theoretical discharge, Q_t = $\sqrt{2gH} \times \dfrac{a_1 \times a_2}{\sqrt{(a_1)^2 - (a_2)^2}}$

Actual discharge, Q_a = $(l \times b \times h) / t$

g – Acceleration due to gravity = 9.81 m/s^2

H - Equivalent column of water = $(h_1 - h_2)\left(\dfrac{s_m - s_l}{s_l}\right)$ in 'm'

a_1 - Area of the pipe (m^2) a_2 - Area of the orifice (m^2)

l – Length of the tank (m) b – Breadth of tank (m)

h – Height of liquid collection (m) t – time for collection (sec)

h_1, h_2 – Deflection in manometer s_m, s_l – Sp. Gravity of manometer and flowing fluid respectively

PROCEDURE:

25. Check up the experimental setup.
26. Measure the length (l) and breadth (b) of the tank.
27. Note the diameter of the pipe line (d_1) and orifice diameter (d_0).
28. Ensure water flow in the pipe line.
29. Open the flow control valve to maximum. Ensure that the mercury levels in the manometer are steady.
30. Allow water to flow for some time.
31. Note the deflections in the manometer (h_1, h_2).
32. Close the tank outlet valve.
33. Note the time ('t' sec) to collect 'h' m height of water in the tank.
34. Open the tank outlet valve.
35. Close the flow control valve slightly and repeat steps 7 to 10.
36. Tabulate the observations.

OBSERVATIONS AND TABULATIONS:

Length of tank, l = ………. (m)

Breadth of tank, b = ………. (m)

Height of collection, h = 0.1 m

Diameter of the pipe, d1 = ……….. (m)

Diameter of throat, d2 = ……….. (m)

Specific gravity of manometric fluid (Mercury), s_m = 13.6

Specific gravity of flowing fluid (Water), s_l = 1.0

Sl. No.	Deflection in manometer			H (m)	$\sqrt{H}$	Time 't' (sec)	Q_a (m^3/s)	Q_t (m^3/s)	C_d
	h_1 (cm)	h_2 (cm)	$h_1 - h_2$ (cm)						
1									
2									
3									
4									
5									

MODEL CALCULATION:

Area of cross section of the tank, A = l X b = …….. X ……...

= …………… (m^2)

Actual discharge, Q_a = (A h) / t

= ………………………….. (m^3 / s)

Area of the pipe, a_1 = $\frac{\pi}{4} \times (d_1)^2$ = ………………………….

= ………………. (m^2)

Area of the Orifice, a_2 = $\frac{\pi}{4} \times (d_2)^2$ = ………………………….

= ………………. (m^2)

Equivalent column of water, H = $(h_1 - h_2)\left(\frac{s_m - s_l}{s_l}\right)$ in 'm'

Theoretical discharge, Q_t = $\sqrt{2gH} \times \frac{a_1 \times a_2}{\sqrt{(a_1)^2 - (a_2)^2}}$

= ………………………….. (m^3 / s)

Coefficient of discharge, C_d = (Q_a / Q_t)

= …………………..

GRAPHS:

Draw the following graphs:

$\sqrt{H}$ Vs Q_a and

H Vs Q_a

From the graph, the value of $\sqrt{H}$ and Q_a between any two points are found out. Using these values C_d is calculated and compared with the average value of C_d found out by calculation.

RESULT:

Average value of C_d (from calculation) =

Value of C_d (from graph) =

4.PERFORMANCE TEST ON A RECIPROCATING PUMP

AIM:

To conduct a performance test on the Reciprocating Pump and to draw the following graphs:

1. Head Vs Discharge
2. Head Vs Power and
3. Head Vs Overall efficiency.

APPARATUS REQUIRED:

1. Reciprocating Pump test rig consisting of
    a) Reciprocating pump
    b) An electric motor to drive the pump
    c) Pressure and vacuum gauges to measure the head
    d) Flow measuring unit
    e) Suitable capacity sump tank with piping
    f) Energy meter to measure the input to the motor
2. A stop clock.

DESCRIPTION OF THE TEST RIG:

The test rig consists of a sump tank to store water. A reciprocating pump is fitted in the rig. Suitable piping with valves for control is provided. A measuring tank with gauge glass and scale is provided to measure the flow. Pressure and vacuum gauges are provided to find out the discharge head and suction head. An energy meter is fitted to measure the input power.

FORMULAE USED:

Output power $= \frac{\gamma Q H}{1000}$ kW

where γ – Specific weight of water 9810 N/m^3

Q – Discharge in m^3/sec

H – Total head in m

Input power $= \frac{n}{t_e} \times \frac{3600}{K}$ kW

where n – No of revolutions of energy meter disc

t_e – Time for 'n' revolutions in 'sec'

K – Energy meter constant in Rev/kW-hr

Overall Efficiency $= \frac{\text{Output}}{\text{Input}} \times 100$ %

PROCEDURE:

1. Ensure that the delivery valve is in closed position.
2. Ensure that the isolation valves of the pressure/vacuum gauges are closed.
3. Prime the pump and start it. Allow it to attain the rated speed.
4. Open the valve fitted to the pressure gauge fitted at the outlet of the pump.
5. Note the following readings at no load:
   a. Vacuum gauge reading at inlet to the pump.
   b. Pressure gauge readings at outlet of each stage.
   c. Time to collect 100 mm height of water in the measuring tank.
   d. Time for 5 revolutions of the disc of energy meter.
6. At different gate valve opening note the readings.
7. Tabulate the readings.
8. Do the calculations and draw the graphs.

TABULATIONS AND CALCULATIONS:

Area of measuring tank	$= 0.3 \times 0.3\ m^2$
Energy meter constant, K	= 1200 Rev/kW-hr
Datum head, Z	= 0.6 m of water
Suction head, H_s	$= (V / 1000) \times 13.6$ m of water
Discharge head, H_d	$= (p \times 10)$ m of water
Total head delivered by the pump, H	$= Z + H_s + H_d$ m of water
Discharge, Q	$= (0.3 \times 0.3 \times 0.1)/t\ m^3/s$
Output power, OP	$= \frac{\gamma Q H}{1000}$ kW
Input power	$= \frac{n}{t_e} \times \frac{3600}{K}$ kW
Efficiency, η	$= (OP / IP) \times 100$ %

TABULATIONS: RECIPROCATING PUMP

Sl No	Vacuum Gauge Reading	Pressure Gauge Readings	Suction Head	Discharge Head	Total Head	Time for 5 revolutions of Energy meter	Time for 100 mm water collection	Discharge	Output	Input	Overall efficiency
	mm of Hg	kg/cm^2	m of water	m of water	m of water	sec	sec	m^3/s	kW	kW	η
	V	p	H_s	H_d	H	t_e	t	Q	OP	IP	%
1											
2											
3											
4											
5											

RESULT:

Performance test on the Reciprocating pump is carried out and the readings and results are tabulated and the graphs are drawn.

5.PERFORMANCE TEST ON A CENTRIFUGAL PUMP

AIM:

To conduct a performance test on the Centrifugal Pump and to draw the following graphs:

4. Head Vs Discharge
5. Head Vs Power and
6. Head Vs Overall efficiency.

APPARATUS REQUIRED:

3. Centrifugal Pump test rig consisting of
   a) Centrifugal pump
   b) An electric motor to drive the pump
   c) Pressure and vacuum gauges to measure the head
   d) Flow measuring unit
   e) Suitable capacity sump tank with piping
   f) Energy meter to measure the input to the motor
4. A stop clock.

DESCRIPTION OF THE TEST RIG:

The test rig consists of a sump tank to store water. A centrifugal pump is fitted in the rig. Suitable piping with valves for control is provided. A measuring tank with gauge glass and scale is provided to measure the flow. Pressure and vacuum gauges are provided to find out the discharge head and suction head. An energy meter is fitted to measure the input power.

FORMULAE USED:

Output power $= \frac{\gamma Q H}{1000}$ kW

where γ – Specific weight of water 9810 N/m^3

Q – Discharge in m^3/sec

H – Total head in m

Input power $= \frac{n}{t_e} \times \frac{3600}{K}$ kW

where n – No of revolutions of energy meter disc

t_e – Time for ‘n’ revolutions in ‘sec’

K – Energy meter constant in Rev/kW-hr

Overall Efficiency $= \frac{\text{Output}}{\text{Input}} \times 100\ \%$

PROCEDURE:

9. Ensure that the delivery valve is in closed position.
10. Ensure that the isolation valves of the pressure/vacuum gauges are closed.
11. Prime the pump and start it. Allow it to attain the rated speed.
12. Open the valve fitted to the pressure gauge fitted at the outlet of the pump.
13. Note the following readings at no load:
    a. Vacuum gauge reading at inlet to the pump.
    b. Pressure gauge readings at outlet of each stage.
    c. Time to collect 100 mm height of water in the measuring tank.
    d. Time for 5 revolutions of the disc of energy meter.
14. At different gate valve opening note the readings.
15. Tabulate the readings.
16. Do the calculations and draw the graphs.

TABULATIONS AND CALCULATIONS:

Area of measuring tank	$= 0.5 \times 0.5\ m^2$
Energy meter constant, K	= 200 Rev/kW-hr
Datum head, Z	= 0.7 m of water
Suction head, H_s	$= (V / 1000) \times 13.6$ m of water
Discharge head, H_d	$= (p \times 10)$ m of water
Total head delivered by the pump, H	$= Z + H_s + H_d$ m of water
Discharge, Q	$= (0.5 \times 0.5 \times 0.1)/t\ m^3/s$
Output power, OP	$= \frac{\gamma Q H}{1000}$ kW
Input power	$= \frac{n}{t_e} \times \frac{3600}{K}$ kW
Efficiency, η	$= (OP / IP) \times 100\ \%$

TABULATIONS: CENTRIFUGAL PUMP

Sl No	Vacuum Gauge Reading	Pressure Gauge Readings	Suction Head	Discharge Head	Total Head	Time for 5 revolutions of Energy meter	Time for 100 mm water collection	Discharge	Output	Input	Over efficie
	mm of Hg	kg/cm^2	m of water	m of water	m of water	sec	sec	m^3/s	kW	kW	η
	V	p	H_s	H_d	H	t_e	t	Q	OP	IP	%
1											
2											
3											
4											
5											

RESULT:

Performance test on the centrifugal pump is carried out and the readings and results are tabulated and the graphs are drawn.

6.LOAD TEST ON A FRANCIS TURBINE

AIM:

To conduct a load test on the Francis turbine at a constant guide vane opening (0.5) and to draw the following graphs:

1. Load Vs RPM
2. Load Vs Input
3. Load Vs Output and
4. Load Vs Efficiency.

APPARATUS REQUIRED:

5. Francis turbine test rig consisting of
   a) Francis turbine
   b) A water supply pump coupled with motor
   c) Flow measuring unit
   d) Piping system
   e) Suitable capacity tank
6. A tachometer.

DESCRIPTION OF THE TEST RIG:

The test rig consists of a tank to store water. A centrifugal pump is fitted in the rig for supplying water under head to the turbine. Suitable piping with control valves is provided. An orifice meter is fitted to measure the flow. Pressure gauges are provided to find out the supply head and head across the orifice meter. A vacuum gauge is fitted to find out the pressure at the outlet of the turbine or at the inlet to the draft tube.

The turbine unit consists of a spiral casing, an outer bearing pedestal, rotor assembly with runner, shaft and brake drum. All are mounted on a sturdy cast iron base plate. A straight conical draft tube is provided for regaining the kinetic energy from the exit water. It facilitates easy access to the turbine which could be mounted at a higher level than the tail race. A rope brake arrangement is provided to load the turbine. A set of ten guide vanes are provided around the periphery of the runner. The output of the turbine can be controlled by adjusting the guide vanes. A hand wheel and suitable link mechanism is provided for this.

TECHNICAL SPECIFICATIONS:

A. FRANCIS TURBINE:

Rated supply head	: 10 metres
Discharge	: 1000 Lpm
Rated speed	: 1200 rpm
Power output	: 1 kW
Runaway speed	: 1750 rpm
Runner diameter	: 160 mm
No of guide vanes	: 10
P.C.D of guide vanes	: 230 mm
Brake drum diameter	: 300 mm
Rope brake diameter	: 15 mm

B. SUPPLY PUMP SET:

Rated head	: 10 metres
Discharge	: 1200 Lpm
Normal speed	: 1440 rpm
Power required	: 5 HP
Size of pump	: 100 mm X 75 mm
Type of pump	: Centrifugal, medium speed, single suction, volute

C. FLOW MEASURING UNIT:

Inlet diameter of Orifice meter	: 80 mm
Orifice meter diameter	: 60 mm
Pressure gauges	: 0 – 2 kg/cm^2 – 2 Nos
Orifice meter constant	: $K = 9.11 \times 10^{-3}$

FORMULAE USED:

Input power $= \dfrac{\gamma Q H}{1000}$ kW where γ – Specific weight of water 9810 N/m^3

Q – Discharge in m^3/sec

H – Supply head in m

$$\text{Output power} = \frac{2\,\pi\,N\,R_e W \times 9.81}{60\,X\,1000}\ \text{kW}$$

where N – Turbine speed in rpm

R_e – Effect radius of Brake drum

W – Net load in Brake drum in kg-f

$$\text{Efficiency} = \frac{\text{Output}}{\text{Input}} \times 100\ \%$$

PROCEDURE:

1. Ensure that the guide vanes in the turbine are in closed position.
2. Ensure that the gate valve just above the turbine is in closed position.
3. Ensure that the isolation valves of the orifice meter pressure gauges are closed.
4. Prime the pump and start it.
5. Slowly open the gate valve situated above the turbine.
6. Open the valve fitted to the pressure gauge fitted at the outlet of the pump.
7. Check whether the pump develops the rated head.
8. If the pump develops the required head, slowly open the turbine guide vanes until the turbine attains the normal speed.
9. Check for vibration of the rig. Check the bearing temperature. Check the pump gland, there should be an occasional drip of water.
10. At no load note the following:
    a. Pressure gauge reading at inlet to the turbine.
    b. Orifice meter pressure gauge readings.
    c. Speed of the turbine.
11. Slightly load the turbine through the rope load arrangement.
12. In addition to the above readings note the following:
    a. Weight on hanger.

b. Spring balance reading.

13. Tabulate the readings.

14. Do the calculations and draw the graphs.

TABULATIONS AND CALCULATIONS:

Guide vane opening	= 0.5
Brake drum diameter, D	= 0.3 m
Rope diameter, d	= 0.015 m
Effective radius of the brake drum, R_e	= (D/2 + d) = 0.165 m
Weight of rope and hanger, w	= 1 kg
Orifice meter constant, K	= 9.11×10^{-3}
Input head to the turbine in ‘m’ of water, H	= p × 10
Orifice meter head in ‘m’ of water, h	= $(p_1 - p_2) \times 10$
Discharge through the turbine, Q	= $K \times \sqrt{h}$ m^3/s
Input power, IP	= γ Q H / 1000 kW
Net brake load, W	= $[(W_1 + w) - W_2]$ kg-f
Turbine output, OP	= $\frac{2\,\pi\,N\,R_e W \times 9.81}{60\,X\,1000}$ kW
Efficiency, η	= (OP / IP) × 100 %

Sl No	Turbine inlet pressure	Turbine Input Head	Orifice meter pressures			Orifice meter head	Discharge	Speed	Weight on Hanger	Spring Balance Reading	Net Load	Output	Input	Efficiency
	kg/cm^2	m of water	kg/cm^2			m of water	m^3/s	RPM	kg-f	kg-f	kg-f	kW	kW	%
	(p)	H	(p_1)	(p_2)	$(p_1 - p_2)$	h	Q	N	W_1	W_2	W	OP	IP	η
1														
2														
3														
4														
5														

RESULT:

Load test on Francis turbine is carried out and the readings and results are tabulated and the graphs are drawn.

7.FLOW THROUGH RECTANGULAR NOTCHE

OBJECTIVES:

To determine the coefficients of discharge of the rectangular notche.

APPARATUS REQUIRED:

Hydraulic bench
Notches – Rectangular,
Hook and point gauge
Calibrated collecting tank
Stop watch

DESCRIPTION

In open channel hydraulics, weirs are commonly used to either regulate or to measure the volumetric flow rate. They are of particular use in large scale situations such as irrigation schemes, canals and rivers. For small scale applications, weirs are often referred to as notches and invariably are sharp edged and manufactured from thin plate material. Water enters the stilling baffles which calms the flow. Then, the flow passes into the channel and flows over a sharp-edged notch set at the other end of the channel. Water comes of the channel in the form of a nappe is then directed into the calibrated collection tank. The volumetric flow rate is measured by recording the time taken to collect a known volume of water in the tank.

A vertical hook and point gauge, mounted over the channel is used to measure the head of the flow above the crest of the notch as shown in Fig. 2.1. Hook gauge can be moved vertically to measure vertical movements.

FORMULAE USED:

A) RECTANGULAR NOTCH

Coefficient of discharge

Actual discharge = Cd × (Theoretical discharge)

$$Q_{th} = \frac{2}{3}\sqrt{2g}\ B\ H^{3/2}$$

So, $$C_d = \frac{Q_{act}}{\frac{2}{3}\sqrt{2g}\ B\ H^{3/2}}$$

Where $$Q_{act} = \frac{\text{ollected}}{\text{Time Taken}}$$

PRECAUTIONS

- Ensure and read initial water level reading just above the crest.

PROCEDURE:

<u>Preparation for experiment:</u>

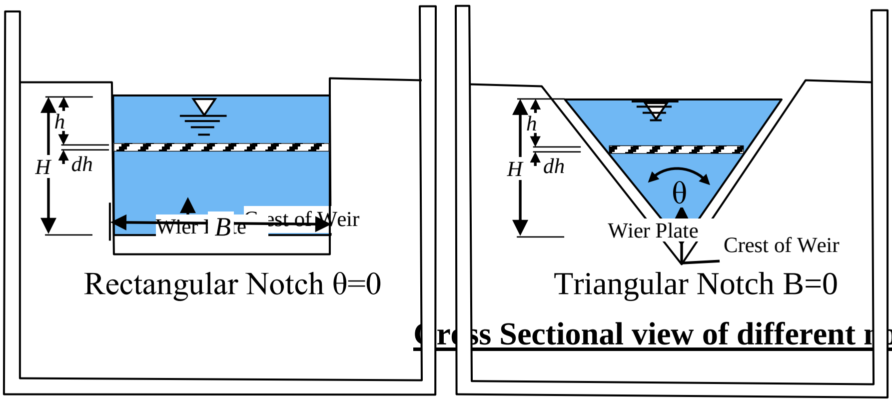
1. Insert the given notch into the hydraulic bench and fit tightly by using bolts in order to prevent leakage.
2. Open the water supply and allow water till over flows over the notch. Stop water supply, let excess water drain through notch and note the initial reading of the water level 'h_0'using the hook and point gauge. Let water drain from

collecting tank and shut the valve of collecting tank after emptying the collecting tank.

Experiment steps:

3. After initial preparation, open regulating valve to increase the flow and maintain water level over notch. Wait until flow is steady.
4. Move hook and point gauge vertically and measure the current water level 'h_1' to find the water head 'H' above the crest of the notch.
5. Note the piezometric reading 'z_0' in the collecting tank while switch on the stopwatch.
6. Record the time taken 'T' and the piezometric reading 'z_1' in the collecting tank after allowing sufficient water quantity of water in the collecting tank.
7. Repeat step 3 to step 6 by using different flow rate of water, which can be done by adjusting the water supply. Measure and record the H, the time and piezometric reading in the collecting tank until 5 sets of data have been taken. If collecting tank is full, just empty it before the step no 3.
8. To determine the coefficient of discharge for the other notch, repeat from step 1.

After entering the readings in the Tabulation 2.1 and Tabulation 2.2, compute the necessary values



Cross Sectional view of different notches

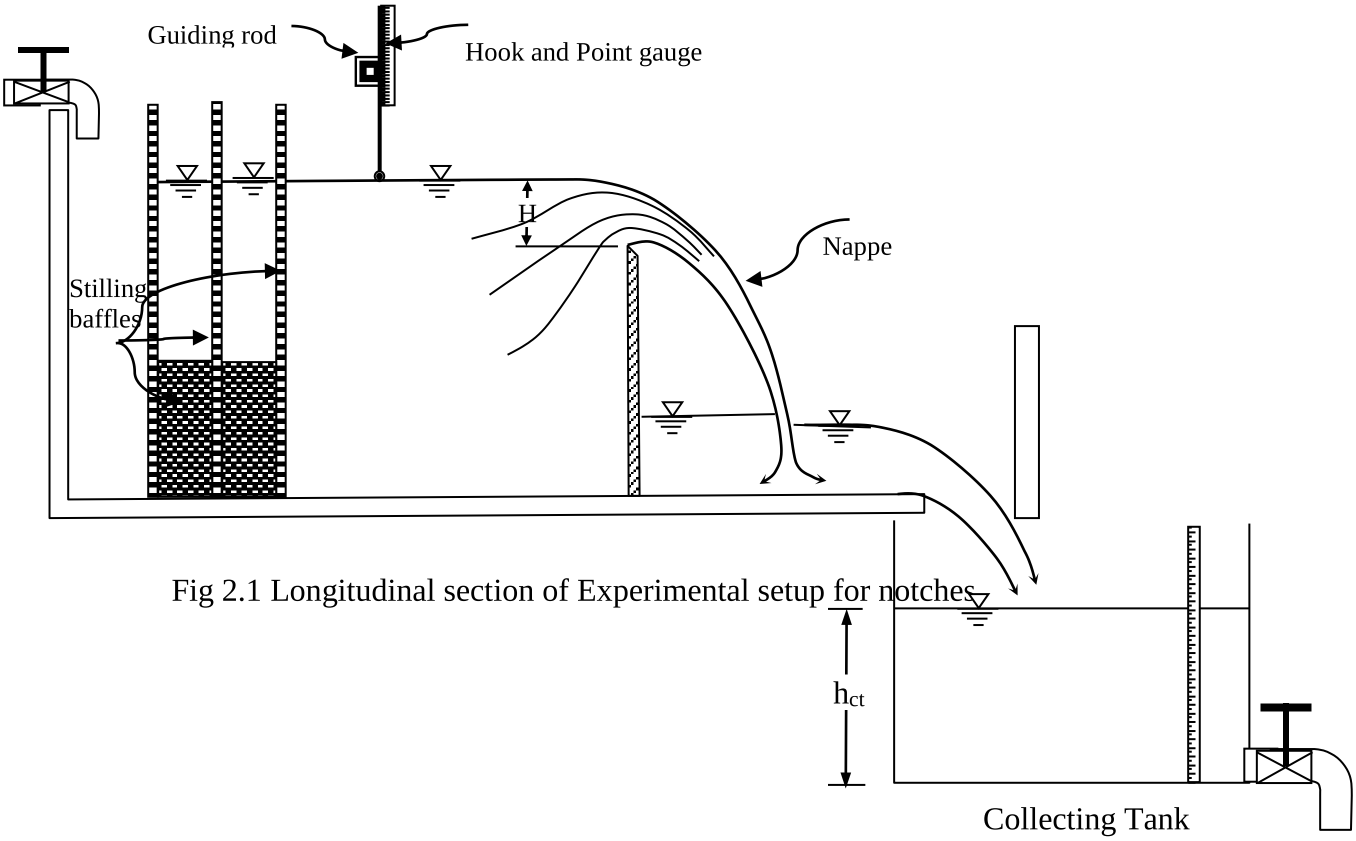


Fig 2.1 Longitudinal section of Experimental setup for notches

OBSERVATION AND COMPUTATIONS – I

A) For Rectangular notch

Notch breadth 'B' = Initial reading of hook and point gauge h_0=

Area of collecting Tank A_{ct} = x = m^3

Tabulation 2.1 – Determination of Cd of rectangular notch.

No. ↓	*Theoretical Discharge Measurement*			*Actual Discharge Measurement*						Cd
	h_1 (m)	H (m)	Theoretical Discharge, $Q_{th} = \frac{2}{3}\sqrt{2g}\, B\, H$	Time T (sec)	z_1 (m)	z_0 (m)	Collecting Tank h_{ct} (m)	Volume (m^3) $A_{ct} * h_{ct}$	Discharge, Q_{act} (9)/(5)	$\frac{Q_{act}}{Q_{th}}$ (10)/(4)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
1										
2										
3										
4										

Rectangular notch : Average Value of Cd = ……………...….

GRAPH:

A). For rectangular Notch:

1- Q_{act} versus H and Q_{act} versus $H^{3/2}$ are drawn taking H and $H^{3/2}$ on *x* -axis and Q_{act} on *y* – axis.

2- C_d versus H is drawn taking H on *x* -axis and Cd on *y* – axis.

3- C_d versus H is drawn taking H on *x* -axis and Cd on *y* – axis.

RESULTS :

Load test on flow through rectangular notche is carried out and the readings and results are tabulated and the graphs are drawn.

8.FLOW THROUGH TRIANGULAR NOTCHE

OBJECTIVES:

To determine the coefficients of discharge of the triangular and notche.

APPARATUS REQUIRED:

Hydraulic bench
Notches – Rectangular, triangular,
Hook and point gauge
Calibrated collecting tank
Stop watch

B) TRIANGULAR NOTCH

Coefficient of discharge

$$Q_{th} = \frac{8}{15}\sqrt{2g}\ H^{5/2}\ \tan\frac{\theta}{2}$$

So, $$C_d = \frac{Q_{act}}{\frac{8}{15}\sqrt{2g}\ H^{5/2}\ \tan\frac{\theta}{2}}$$

PRECAUTIONS

- Ensure and read initial water level reading just above the crest.

PROCEDURE:

Preparation for experiment:

9. Insert the given notch into the hydraulic bench and fit tightly by using bolts in order to prevent leakage.
10. Open the water supply and allow water till over flows over the notch. Stop water supply, let excess water drain through notch and note the initial reading of the water level 'h_0'using the hook and point gauge. Let water drain from collecting tank and shut the valve of collecting tank after emptying the collecting tank.

Experiment steps:

11. After initial preparation, open regulating valve to increase the flow and maintain water level over notch. Wait until flow is steady.
12. Move hook and point gauge vertically and measure the current water level 'h_1' to find the water head 'H' above the crest of the notch.

13. Note the piezometric reading ‘z_0’ in the collecting tank while switch on the stopwatch.
14. Record the time taken ‘T’ and the piezometric reading ‘z_1’ in the collecting tank after allowing sufficient water quantity of water in the collecting tank.
15. Repeat step 3 to step 6 by using different flow rate of water, which can be done by adjusting the water supply. Measure and record the H, the time and piezometric reading in the collecting tank until 5 sets of data have been taken. If collecting tank is full, just empty it before the step no 3.
16. To determine the coefficient of discharge for the other notch, repeat from step 1.

After entering the readings in the Tabulation 2.1 and Tabulation 2.2, compute the necessary values.

For Triangular notch

Notch angle ‘θ’ = Initial reading of hook and point gauge h_0=

Area of collecting Tank A_{ct} = x = m^3

Tabulation 2.2 – Determination of Cd of triangular notch.

No.↓	*Theoretical Discharge Measurement*			*Actual Discharge Measurement*						Cd
	h_1 (m)	H (m)	Theoretical Discharge, $Q_{th} = \frac{8}{15}\sqrt{2g}\ H^{5/2} \tan\frac{\theta}{2}$	Time T (sec)	z_1 (m)	z_0 (m)	Collecting Tank h_{ct} (m)	Volume (m^3) $A_{ct*}\ h_{ct}$	Discharge, $\mathbf{Q}_{act}$ (9)/(5)	$\mathbf{Q_{ac}}$ / $\mathbf{Q_{th}}$ (10)/
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11
1										
2										
3										
4										

Triangular notch: Average Value of Cd = ……………...….

GRAPH:

A). For triangular Notch:

4- Q_{act} versus H and Q_{act} versus $H^{5/2}$ are drawn taking H and $H^{5/2}$ on *x* -axis and Q_{act} on *y* – axis.

5- C_d versus H is drawn taking H on *x* -axis and Cd on *y* – axis.

RESULTS :

Load test on flow through triangular notche is carried out and the readings and results are tabulated and the graphs are drawn.

9.PELTON WHEEL TURBINE

OBJECTIVES:

To study the operation of Pelton wheel turbine and to measure the power output of a Pelton Wheel turbine.

To obtain the performance characteristics (Output, efficiency variation with speed) for different openings of the nozzle at a constant speed.

APPARATUS REQUIRED:

Pelton wheel unit inside a casing with a transparent window, supply pump, venturi meter with pressure gauge, tachometer, pressure gauge at the inlet to the turbine, rope brake drum with spring balance connected to the turbine.

FORMULAE USED:

Assuming that the speed of the exiting jet is zero (all of the kinetic energy of the jet is expended in driving the buckets), negligible head loss at the nozzle and at the impact with the buckets (assuming that the entire available head is converted into jet velocity)

1). Power Available to the turbine $P_{input} = \rho.g.Q.H$

where

ρ is the density of water,

g is the acceleration due to gravity,

Q can be calculated using venurimeter pressure reading as:

$$Q = C_d K \frac{\pi {d_2}^2}{4} \sqrt{\frac{2(p_1 - p_2)}{\rho}}$$

where Cd is the coefficient of discharge venturi meter

$$K = \sqrt{\frac{1}{1 - \left(\frac{d_2}{d_1}\right)^4}}$$

d_1, d_2 are inner diameters of the venturi inlet and the throat respectively

p_1, p_2 are pressure readings at the inlet and the throat of venturi meter respectively

H is the available head which can be computed from the P_i .

H = 10 * Pi. (in m), if Pi is measured in kg/cm^2.

By applying the angular momentum equation (assuming negligible angular momentum for the exiting jet),

2). The power developed by the turbine on the shaft of brake drum can be written as:

$$P_{output} = T.\omega = (W - S).g.r.\frac{2\pi N}{60}$$

where

T is the torque on the rotor (shaft),

ω is the rotational speed of the rotor (shaft),

W is the mass in kg.

g is the acceleration due to gravity, (m/sec^2)

r is the radius of the brake drum + half thickness of rope.

N is rpm of the brake drum shaft.

PRECAUTIONS

- Ensure all the gauges read zero under no load, no flow conditions.
- Allow the cooling water to flow along the brake drum when the turbine runs under load.
- Keep the spear valve closed until the supply pump develops necessary head.
- Load the turbine gradually.
- Let the speed of the turbine stabilize after each change in the load before taking the readings.
- Remove the load on the brake drum before switching off the supply.

PROCEDURE:

1. Note the nozzle diameter, pipe diameter, veturimeter specifications. Measure brake drum diameter and datum head (Distance between pressure gauge tapping and center line of the nozzle). Keep the brake drum loading minimum.
2. Keep the spear valve and inlet valve closed. Start the pump. Keeping the spear valve under closed condition, gradually open the delivery valve to the maximum.
3. Open the nozzle little more (initially around quarter of full opening) with the help of needle valve.
4. Adjust the load on the brake drum to keep the speed limits.
5. Note the venturi meter pressure gauge readings 'p_v" for measuring the discharge 'Q'.
6. Note the turbine pressure gauge reading P_i.
7. Note the spring balance reading and weight (S and W) and measure the shaft speed (N).
8. Take 8 readings of 'N', in the allowable range of speed by varying the load (S and W) on the brake drum.
9. Repeat steps 3 to 8 for at least 4 different nozzle openings.

After entering the readings in the Tabulation 8.1 to 8.4, compute the necessary values.

OBSERVATION AND COMPUTATIONS – I

Density of water ρ = 1000 kg/m^3
Brake drum radius r1 = ... m   Rope radius r2 = ... m
r=(r1+r2) =. . . . . m
Mass of hanger M_h = ... Kg
Acceleration due to gravity g = 9.81 m/s^2 m
Venurimeter constants Cd =   K = ……………… A_v = m^2

A) For 0.25% opening of spear valve.

Pressure head available P_i = ... kg/cm^2 H= 10 P_i = ... m
Venturi Meter Readings reading P_1 = ... kg/m^2 P_2 = ... kg/m^2 Q = m^3/s

Tabulation 8.1 – For 0.25% opening of spear valve

No	W (kg)	S (kg)	Time (s)	Tachometer reading	N (rps)	Torque T	P_{input}	P_{output}	Efficiency η

OBSERVATION AND COMPUTATIONS – II

A) For 0.50% opening of spear valve.

Pressure head available P_i = ... kg/cm^2 H= 10 P_i = ... m
Venturi Meter Readings reading P_1 = ... kg/m^2 P_2 = ... kg/m^2 Q = m^3/s

Tabulation 8.2 – For 0.50% opening of spear valve

No	W (kg)	S (kg)	Time (s)	Tachometer reading	N (rps)	Torque T	P_{input}	P_{output}	Efficiency η

OBSERVATION AND COMPUTATIONS – III

A) For 0.75% opening of spear valve.

Pressure head available P_i = ... kg/cm^2 H= 10 P_i = ... m
Venturi Meter Readings reading P_1 = ... kg/m^2 P_2 = ... kg/m^2 Q = m^3/s

Tabulation 8.3 – For 0.75% opening of spear valve

No	W (kg)	S (kg)	Time (s)	Tachometer reading	N (rps)	Torque T	P_{input}	P_{output}	Efficiency η

OBSERVATION AND COMPUTATIONS – IV

For full opening of spear valve.

Pressure head available P_i = ... kg/cm^2 H= 10 P_i = ... m
Venturi Meter Readings reading P_1 = ... kg/m^2 P_2 = ... kg/m^2 Q = m^3/s

Tabulation 8.1 – For full opening of spear valve

No	W (kg)	S (kg)	Time (s)	Tachometer reading	N (rpm)	Torque T	P_{input}	P_{output}	Efficiency η

GRAPH:

1- Plotted Torque vs. Shaft speed N and the curves for same Q are drawn, taking N on *x* -axis and Torque on *y* – axis
2- Plotted Power output vs. Shaft speed N and the curves for same Q are drawn, taking N on *x* -axis and Power output on *y* – axis
3- Plotted efficiency η vs. Shaft speed N and the curves for same Q are drawn, taking N on *x* -axis and η on *y* – axis

RESULTS :

Load test on flow through pelton wheel is carried out and the readings and results are tabulated and the graphs are drawn.