TRIBHUVAN UNIVERSITY

INSTITUTE OF ENGINEERING

PULCHOWK CAMPUS

DEPARTMENT OF CIVIL ENGINEERING

Hydraulics

SUBMITTED BY

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PULCHOWK CAMPUS

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TITLE: DETERMINATION OF MANNING'S COEFFICIENT

Objectives:

(i) To determine Manning's coefficients for the flume or bed of the channel with the flow of water.

(ii) To investigate the roughness of the bed as required as the design.

SCOPE:

Using Manning's formula, we can investigate the roughness of different types of beds of the flume and that of river bed. It helps to know the roughness of bed while designing open flow.

APPARATUS REQUIRED:-

(i) Long lenthened flume (7.1m)

(ii) Needle gauge

(iii) Orifice meter

(iv) Types of bed.

THEORY

We have the relation,

$$V = \frac{1}{n} R^{2/3} S_0^{1/2}$$

where,

V = velocity of flow

n = Manning's coefficient

R = Hydraulic radius = $\frac{\text{wetted Area}}{\text{wetted Perimeter}}$

S_0 = Bed slope

For given rectangular channel, $R = \frac{A}{P} = \frac{bd}{b+2d}$; d = flow depth

Also, $Q = AV$; Q = discharge rate (orifice)

or, $Q = A\sqrt{2gH}$; H = head difference

Also, $Q = A \times \frac{1}{n} R^{2/3} S_0^{1/2}$

$$n = \frac{A R^{2/3} S_0^{1/2}}{Q}$$

$Q_{pipe} = Q_{channel}$

$d_{pipe} = 4''$

$d_{opening} = 60\ mm$

1.25m × 6 = 7.5m

Top 8 : To determine the Manning's coefficient in different types of beds.

Bedslope: 1 : 500

Length: 6m

Observation Table

Obs. No.	Depth of the flume	With of flume	in the head $H_1 - H_2$
1	42.9	300	608 - 580 = 28
2	43.5		730 - 625 = 105
3	45.3		852 - 688 = 164
4	47.4		950 - 730 = 220
5	46.2		946 - 757 / 985 - 795 = 190
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			
21			

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EXPERIMENTAL PROCEDURE:

(i) The pump was started and water was allowed to flow through the flume of certain head difference.

(ii) The head difference and the wetted depth was observed and noted.

(iii) The flow of water and depth was varied for next observations.

(iv) Similarly, the procedure was repeated and number of reading were taken.

OBSERVATIONS

width of flume = 30cm

Sample calculation

width, $b = 0.3\,m$

depth of flume, $d = 42.9\,mm = 0.0429\,m$

Area, $A = bd = 0.0129\,m^2$

wetted perimeter, $P = b + 2d = 0.3858\,m$

So Hydraulic radius, $R = A/P = 0.0334\,m$

velocity, $V = \sqrt{2gh} = \sqrt{2 \times 9.81 \times 0.028} = 0.7412\,m/s.$

Discharge, $Q = AV = 0.0129 \times 0.7412 = 0.0096\,m^3/s.$

Manning's coefficient, $n = \dfrac{AR^{2/3} S_0^{1/2}}{Q}$

$= 0.0062.$

Similar calculations being made, datas are entered in the table as below:-

No. of obs	Velocity v(m/s)	Depth d(m)	Width (b)(m)	Bed slope, S_0	Area(A) = bd, m^2	Hydraulic radius (R), m	Discharge (Q), m^3/s	Manning's coefficient, n
1	0.7412	0.0429			0.0129	0.0334	0.0095	0.0063
2	1.4353	0.0435			0.0131	0.0337	0.0187	0.00326
3	1.794	0.0453	0.300	$\frac{1}{500}$	0.0136	0.0348	0.0244	0.00265
4	2.077	0.0474			0.0142	0.0360	0.0295	0.00235
5	1.931	0.0462			0.0139	0.0353	0.0268	0.0025

Average value of Manning's constant, $n = \frac{0.0170}{5} = 0.0034$

RESULT AND CONCLUSION

From the experiment, Manning's coefficient for a bed slope 1:500 was calculated as 0.0034 and it varied as per depth.

The value of n decreases as discharge increases.

TITLE: OPEN CHANNEL FLOW (HYDRAULIC JUMP)

Objectives:

To compare the experimental value of depth before hydraulic jump to that calculated from theory and calculate the energy loss in hydraulic jump.

SCOPE:

The formation of hydraulic jump is related with a sudden rise in water depth, large scale turbulent and dissipation of energy. It is employed at the foot of spillways and other hydraulic structures to dissipate energy for the protection of bed against scour. This experiment helps to understand the features of hydraulic jump.

Apparatus Required:

(i) Open chanel flume
(ii) Stop watch

THEORY

Hydraulic jump is created by changing the slope or placing a flow weir in the bed of the channel. It is mainly used to dissipate energy and reduce velocity.

Here,

$$\frac{2q^2}{g} = y_1 \cdot y_2 (y_1 + y_2)$$

where, y_1 = depth before jump
y_2 = depth after jump
q = unit discharge
g = acceleration due to gravity

and Energy loss $= \dfrac{(y_2 - y_1)^3}{4 y_1 y_2}$

(b) Adjust the flow rate to give about 300mm head above the sluice.

(c) Raise the adjustable weir to form a hydraulic jump within the central portion of the flume.

(d) Note the depth before and after the jump.

(e) Measure the flow rate and head.

(f) Repeat for a head of 500mm above the sluice and repeat steps c, d & e.

OBSERVATIONS :

Gate opening = 18mm

Channel width = 102 mm

Number of observations	Head in mm	Depth Y_1 mm	Depth Y_2 mm	Volume m^3	Time Sec.
1	223	12.8	~~64.5~~ 62.3	0.1	61 sec.
2	~~252~~ 276	12.4	72.9	0.1	40 sec.
3	~~510~~ 507	12.3	103.2	0.1	30 sec.

CALCULATIONS :

(a) Discharge per unit width q.

(b) Use q and Y_2 to comute Y_1.

(c) Compute E using theoretically derived Y_1 and experimental value.

(d) Show the figure of the apparatus and simple description

PRESENTATION :

(a) Present a sample calculation.

(b) Present the results in a tabular form.

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EXPERIMENTAL PROCEDURE:

(1) The pump was started and sluice gate was opened to about 25mm.

(2) The flow rate was adjusted to give about 300mm bed above the sluice.

(3) The adjustable weir was raised to form a hydraulic jump within the control portion of the flume.

(4) The depth was noted before and after the jump.

(5) The flow rate and head was measured.

(6) The procedure was repeated for a head of 500mm above gate.

Calculations:

(a) discharge per unit width, $q_1 = \frac{(V/t)}{d} = \frac{(0.1/61)}{0.102} = 0.0161$ $(m^3/s)/m$

$q_2 = \frac{(0.1/40)}{0.102} = 0.0245$ $(m^3/s)/m$

$q_3 = \frac{(0.1/30)}{0.102} = 0.0327$ $(m^3/s)/m$

(b) We know,

$y_1 y_2 (y_1 + y_2) = \frac{2q^2}{g}$

for, $q_1 = 0.0161$ m^2/s and $y_2 = 0.0623m$

$\frac{2 \times (0.0161)^2}{g} = y_1 \times 0.0623(0.0623 + y_1)$

$[y_1 = 0.0115m = 11.5mm]$

Similarly for $q_2 = 0.0245$ m^2/s and $y_2 = 0.0729m \Rightarrow [y_1 = 0.0184m = 18.4mm]$.

And, for $q_3 = 0.0327$ m^2/s, $y_2 = 0.1032m$,

$[y_1 = 0.0175m = 17.5mm]$

Sample calculation

Energy loss $(E_1) = \frac{(y_2 - y_1)^3}{4 y_1 y_2}$

So, $E_{th1} = \frac{(0.0623 - 0.0115)^3}{4 \times 0.0623 \times 0.0115} = 0.046$ m of water head

and $E_{th2} = 0.0302$m of water head; $E_{th3} = 0.0871$ m of water head.

RESULT TABLE:

No. of obs.	Discharge, Q (m^3/s)	Unit discharge ($m^3/s/m$)	y_1, mm Theoretical.	Experimental, E_1 (m)	Theoretical E_1 (m)
1.	0.00164	0.0161	12.8	0.038	0.046
2.	0.0025	0.245	12.4	0.0612	0.0302.
3.	0.0033	0.0327	12.3	0.148	0.0871

CONCLUSION:

In the experiment, the value of depth before jump has been found and compared to the theoretical value. Similarly, energy loss was also seen and calculated.

The phenomenon is useful in reducing velocity of flow by dissipating energy through jumps in open channel.

It seems there was noticeable difference between two values (theoretical and experimental) but were within the permissible range. These errors might have occured due to observational errors, instrumental errors. and inaccuracy in devices. However, the experiment was set and studied as an example useful for reducing flow velocity by dissipating energy through jumps in open channel.

It is equally important in raising water level in irrigation channels, mixing of chemicals and preventing erosion in dams.

TITLE: HEAD LOSS IN PIPE LINE

Objective:

To study the head loss due to friction in pipes and compare the value with existing data.

SCOPE:

The transmission of fluid through pipes is a practical problem faced by an engineer. Distribution of water for domestic purposes, flow of liquid in processing industries, pumping of water and oil, passing the steams in thermal plants and flow of gas through pipes to consumers are some examples of flow of fluid through conduits. The flow of fluid through pipes is associated with energy loss. The cases for designing pipes for above purposes in the accurate determination of loss of energy incured during flow. The estimation of friction loss also enables us to determine the type and capacity of pump required and the power consumption.

Apparatus Required:

(i) Pipe network

(ii) Thermometer

THEORY

The head loss due to friction in a pipe flow according to Darcy-Weibsach's equation is given by

$$h_L = \frac{fLV^2}{2gD} \quad \text{for circular pipe section}$$

where, f = friction factor

L = length of pipe

V = velocity of flow

g = acceleration of gravity

D = Diameter of pipe

and $V = Q/A$

where, Q = discharge rate

A = Area of cross-section

(j) Repeat for seven more flows.

(k) Repeat (b) to (j) for larger diameter two pipes.

(l) Observe water temperature.

Rotameter → L/hr

OBSERVATIONS :

Temp → 13°C

Length → 2m

Temperature of water =

Number of observations	PIPE DIAMETER					
	1/2"		3/4"		1"	
	Q_1/hr (Litres/hr)	$h_2 - h_1$ mm	Q_1/hr	$h_2 - h_1$ mm	Q_1/hr	$h_2 - h_1$ mm
1	200	336-314	=22			
2	300	354-305	=49			
3	400	372-290	=82			
4	500	390-271	=119			
5	600	405-250	=155			
6	700	433-232	=201			
7	800	470-212	=258			
8	900	510-191	=319			

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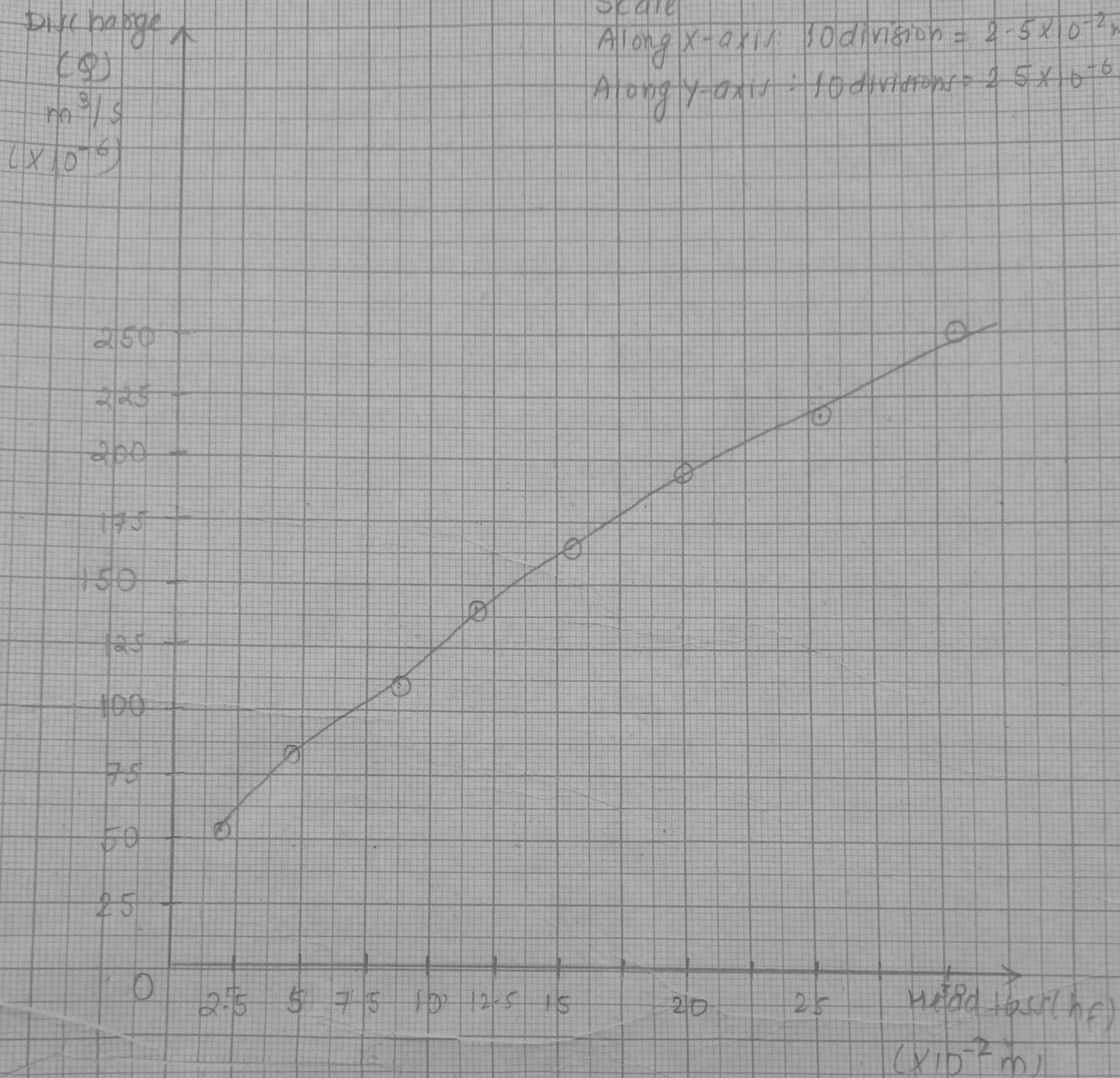
Graph of Q v/s h_f

Scale:
Along X-axis: 10 division = 2.5×10^{-2} m
Along Y-axis: 10 divisions = 2.5×10^{-6} m^3/s



EXPERIMENTAL PROCEDURES

(1) The apparatus was set and the pump was started.
(2) The pipes were selected and by operating appropriate valves, flow was allowed to pass through the system.
(3) The pressure tappings were connected at the pipe to the manifold by operating small cocks so that the manometer comes in contact with water in pipe. and water level was brought to some appropriate level in the manometer and air vent was closed.
(4) Operating the drain cocks, in the manometer and the air-vent, the water level was brought to a level, pressure tappings being disconnected right after.
(5) The flow control was regulated and a small discharge was allowed to pass through pipe.
(6) Then, the manifold cock was opened so that the manometer liquid would stand at two different heights.
(7) The pressure difference given by height difference was noted and discharge was recorded.
(8) The water temperature was also recorded and process was repeated.

OBSERVATIONS:

Temperature of water = $13^\circ C$

length of pipe = 2m

Calculation.

For observation 1,

(a) Discharge, Q_a = 200 litres/hr = $0.2 m^3/hr$

(b) Pipe diameter, $d = (1/2)'' = \frac{1}{2} \times 2.54 = 1.27 cm$

(c) Area, $A = \frac{\pi}{4} d^2 = \frac{\pi}{4} \times (1.27)^2 = 1.267 cm^2 = 1.267 \times 10^{-4} m^2$

(d) velocity, $V = Q/A = \frac{0.2/3600}{1.267 \times 10^{-4}} = 0.438 m/s$

(e) At $13^\circ C$,

viscosity of water, $\mu = 1.2005 \times 10^{-3} Ns/m^2$

density of water, $\rho = 0.9994 g/cm^3 = 999.4 kg/m^3$

Now, head loss, $h_f = \frac{f l V^2}{2gd}$

$d = 1.27 \times 10^{-2}$ m

head loss, $h_f = 336 - 314 = 22$ mm $= 0.022$ m.

$\Rightarrow f = \frac{2gd}{lV^2} \times h_f$

$= \frac{2 \times 9.81 \times 1.27 \times 10^{-2}}{2 \times (0.438)^2} \times 0.022 = 0.0143.$

and $Re = \frac{V \rho d}{\mu} = \frac{0.438 \times 999.4 \times 1.27 \times 10^{-2}}{1.2005 \times 10^{-3}} = 4630.79$ (>4000) (Turbulent flow)

RESULT TABLE :

S.N.	Flow rate, m^3/s	velocity, m/s	$Re = \frac{\rho V d}{\mu}$	h_f (m)	friction factor
1	0.2/3600 $= 55.56 \times 10^{-6}$	0.438	4630.79	0.022	0.0143
2	83.33×10^{-6}	0.658	6953.81	0.049	0.0141
3	111.11×10^{-6}	0.877	9271.75	0.082	0.0132
4	138.89×10^{-6}	1.096	11589.69	0.119	0.0123
5	166.67×10^{-6}	1.315	13907.63	0.155	0.0112
6	194.44×10^{-6}	1.535	16225.56	0.201	0.0106
7	222.22×10^{-6}	1.754	18543.50	0.258	0.0104
8	250×10^{-6}	1.973	20861.44	0.319	0.0102

Average friction factor, $\bar{f} = \frac{\Sigma f}{n} = \frac{0.09644}{8} = 0.01206$

standard deviation, $s = 0.00167$

$\therefore f = (0.01206 \pm 0.00167)$

CONCLUSION:

Hence, from this experiment, we observed the head loss due to friction in pipe. It was observed that with the increase of Reynold's number, the friction factor decreased. Head loss and Discharge seem to have direct ~~linear~~ relation. There may have been observational and experimental errors but the results seem to be in permissible range.

TITLE: FLOW THROUGH OPEN CHANNEL SLUICE GATE

OBJECTIVE:

To investigate the operating characteristics of a sluice gate in open channels.

SCOPE:

Sluice gates are used in irrigation systems to control the flow rates. The study of characteristics of sluice gates provides the informations associated for their hydraulic design.

APPARATUS

(i) Open channel flume
(ii) Stop watch

Theory

(i) Flow through a rectangular orifice is given by,

$Q_{th} = A\sqrt{2gH}$ where, Q_{th} = Theoretical Discharge
A = Area of gate opening
H = Head.

(ii) Coefficient of discharge,

$$C_d = \frac{Q_{experimental}}{Q_{theoretical}}$$

(iii) Actual discharge (experimental)

$$Q_{act} = \frac{Volume}{Time}$$

EXPERIMENTAL PROCEDURES

(1) The pump was started and water was allowed to flow through the flume with the value set of minimum opening.
(2) The gate opening was set at 25mm.
(3) The flow control gate wa operated to give a head of about 100mm in the tank for a while.
(4) The flow rate was determined by taking time for a known value of water passing through the flow-meter at the bottom.
(5) The inlet head was noted.
(6) The gate opening was increased to 50mm and 75mm while the head at 100mm by operating the flow-control valve and measuring discharge at each.

(b) Set the gate opening at 25mm.

(c) Operate the flow control valve to give a head of about 100mm in the tank and allow the condition to settle.

(d) Determine the flow rate by timing a known volume (m^3) passing through the flow meter at the bottom.

(e) Note the inlet head.

(f) Now increase the gate opening to 50mm and 75mm while keeping the head at 100mm by operating the flow control valve, measure discharge at each step.

(g) Repeat the procedure for heads in the tank of 15mm, 200mm, 250mm, 300mm and 350mm for the sluice gate opening of 25mm, 50mm and 75mm.

OBSERVATIONS :

Width of the flume =

Number of observations	Head mm	Gate Opening mm	Volume m^3	Time Sec.
1	100	25	0.1	61.24Sec
		50	0.1	42.46
		75	0.1	35.01
2	150	25	0.1	48.47
		50	0.1	26.91
		75	0.1	19.61
3	200	25	0.1	~~42~~ 41.18
		50	0.1	19.06
		75	0.1	14.00
4	250	25	0.1	32.61
		50	0.1	16.27
		75	0.1	11.37
5	300	25	0.1	27.54
		50	0.1	14.61
	H=285	for 75 mm only	0.1	10.51 sec
6	350	25	0.1	
		50	0.1	
		75	0.1	

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(7) The procedure was repeated for heads of 150mm and 200mm, 250mm, 300mm, and 350mm, for sluice gate opening of 25mm, 50mm and 75mm.

Calculations.

For head = 100mm   width of flume = 100mm

Gate opening = 25mm = d

volume = 0.1 m^3

time, t = 61.24 seconds

width, b = 100mm = 0.1m

Area, A = bd = 0.1 × 0.025 = 0.0025 m^2

(a) Actual discharge, $Q = \frac{\text{volume}}{\text{time}}$

$= 0.00163 \, m^3/s.$

(b) Theoretical Discharge, $q_{th} = A\sqrt{2gH}$

$= 0.0025\sqrt{2 \times 9.81 \times 0.1}$

$= 0.0035 \, m^3/s$

(c) coefficient of discharge, $C_d = \frac{q_{act}}{q_{th}}$

$= 0.466$

Similarly, calculation for other observations are tabulated as follows:-

RESULT TABLE width, $b = 0.1m$

No. of obs.	Head, H (mm)	Gate opening, d (mm)	Area (A) (m^2)	Actual discharge (Q_{act}) m^3/s	Theoretical Discharge, Q_{th} (m^3/s)	Coefficient of discharge, Cd
1	100	25	2.5×10^{-3}	1.63×10^{-3}	3.5×10^{-3}	0.4663
		50	5×10^{-3}	2.35×10^{-3}	7×10^{-3}	0.3366
		75	7.5×10^{-3}	2.86×10^{-3}	0.0105	0.2719
2	150	25	2.5×10^{-3}	2.06×10^{-3}	4.29×10^{-3}	0.481
		50	5×10^{-3}	3.72×10^{-3}	8.58×10^{-3}	0.433
		75	7.5×10^{-3}	5.1×10^{-3}	0.0129	0.3963
3	200	25	2.5×10^{-3}	2.43×10^{-3}	4.9×10^{-3}	0.4903
		50	5×10^{-3}	5.2×10^{-3}	9.90×10^{-3}	0.5297
		75	7.5×10^{-3}	7.14×10^{-3}	0.0149	0.481
4	250	25	2.5×10^{-3}	3.07×10^{-3}	5.54×10^{-3}	0.554
		50	5×10^{-3}	6.15×10^{-3}	0.0111	0.555
		75	7.5×10^{-3}	8.8×10^{-3}	0.0166	0.529
5	300	25	2.5×10^{-3}	3.63×10^{-3}	6×10^{-3}	0.599
		50	5×10^{-3}	6.84×10^{-3}	0.0121	0.564
	H = 285mm	75	7.5×10^{-3}	9.51×10^{-3}	0.0177	0.5365

$$\text{Average value of } Cd = \frac{7.2237}{15} = 0.4816.$$

CONCLSION

In this experiment, head and corresponding flow rate was observed. the actual and theoretical value of discharge were calculated for rectangular open channel and coefficient of discharge was found in the range of 0.272 to 0.599. The result clearly shows that the value of Cd decreases with the increase in sluice gate, for same head. It is useful in flow of water in dams. Also, the flow rate increases with increase with gate opening and head.