INVESTIGATION ON PERFORMANCE OF VENTURI FLUMES

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IN

CIVIL ENGINEERING

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CERTIFICATE

This is to certify that the Project Report entitled "INVESTIGATION ON PERFORMANCE OF VENTURI FLUMES" submitted by

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Dedicated to my beloved parents, and teachers who have worked hard throughout my education.

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Abstract

Flumes are specially shaped engineered structures that are used to measure the flow of water in the open channels. Venturi flume is a very popular flow measuring device. Many devices have been developed for the measurement of water under field conditions for example, in it's delivery to irrigators. Venturi flume consists essentially of a flume with a converging and diverging section and short "throat" section between them. In this project we "Design the Venturi Flumes and Check the Performance of the Venturi Flumes".

Methodology as follows the study of flumes, Performing Experiment on Existing Set Up (Hydraulic Tilting flume) and determines the co-efficient of discharge. Designing the venturi flume with Rectangular venturi flumes using code book (IS 4359-2012) .Trapezoidal and V-shape venturi flumes are designed by using area constant method. Experimentations are done for Rectangular, Trapezoidal and V-shape venturi flumes by varying the discharge's measuring the depths along the shape at different intervals. From this, graphs are plotted for average depth of upstream to throat to the discharge and also the profile of the water flow. The equations are drawn to the discharge to Avg depth by using Excel.

The Froude's number is calculated using velocity of flow, depth of flow and acceleration due to gravity. Aspect ratio is calculated using average breadth and average depth. The Graphs are plotted between the Froude's number and Aspect ratio. If the Aspect ratio is more the effect of side wall is less. Based on this values Rectangular venturi flumes has higher Aspect ratio, So side wall effect is less.

Keywords: Hydraulic Tilting Flume, Venturi Flumes, Excel, Froude's Number, Aspect Ratio and Discharge Equations.

Notations

t	Time
V	Velocity
B	Breadth
h_1	Left limb
h_2	Right limb
Q	Discharge
S_0	Flat Slope
S_1	1 in 180 Slope
S_2	1 in 60 Slope
AR	Aspect Ratio
R	Rise of Water
H	Pressure Head
y	Depth of Water
B_1	Average Breadth
F	Froude's Number
Q_{act}	Actual Discharge
Q_{th}	Theoretical Discharge
A_c	Area of Collecting Tank
L_1	Convergent Transition Length
L_2	Throat Transition Length
L_3	Divergent Transition Length
S_w	Specific Gravity Of Water
S_m	Specific Gravity Of Mercury
A_1	Inlet Area Of Venturi Meter
A_2	Throat Area Of Venturi Meter
C_d	Coefficient of Discharge of Venturi Meter
A_V	Cross Sectional Area of V-Shape Venturi Flume
A_{Tre}	Cross Sectional Area of Trapezoidal Venturi Flume
A_{Rct}	Cross Sectional Area of Rectangular Venturi Flume

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Chapter 1

Introduction

1.1 Flumes

A Flume is a human-made channel for water in the form of an open declined gravity chute whose walls are raised above the surrounding terrain, in contrast to a trench or ditch. Flumes are not to be confused with aqueducts, which are built to transport water, rather than transporting materials using flowing water as a flume does.[citation needed] Flumes route water from a diversion dam or weir to a desired material collection location.

Many flumes took the form of wooden troughs elevated on trestles, often following the natural contours of the land. Originating as a part of a mill race, they were later used in the transportation of logs in the logging industry, known as a log flume. They were also extensively used in hydraulic mining and working placer deposits for gold, tin and other heavy minerals.

Figure 1.1: flume

1.1.1 Advantages of Flumes

- While similar in accuracy, flumes have distinct advantages over weirs, including.

- The ability to measure higher flow rates than a comparably sized weir
- Less head loss (generally 1/4th that of a weir)
- The ability to pass debris more readily
- Wide range of styles and sizes
- Smaller installation footprint
- Less rigorous maintenance requirements

1.2 Venturi Flumes

Many devices have been developed for the measurement of water under field conditions for example, in its delivery to irrigators. Nearly all of these devices employ the principles of either the weir or the orifice and, though each device is adopted to use ih certain localities, probably none works satisfactorily under a great variety of field conditions. The ideal measuring device would

1. be inexpensive to construct.
2. be simple to operate.
3. require little maintenance.
4. be free from working parts.
5. be accurate in its measurement.
6. be free from sand, silt, or floating trash troubles.
7. require but little loss of head in the ditch.

Such a panacea for all measurement-of-water ills does not seem probable, but progress is undoubtedly being made toward that end. The type of flume tested in the experiments on which this report is based possesses many of the qualities enumerated and may prove to be a satisfactory measuring device under general field conditions.

The purpose of this article is to present the fundamental plans and results of preliminary experiments on a new type of device, called the "Venturi Flume" for measuring water in open channels, in order that those in practical need of such a device may know of its existence.

Furthermore, it is hoped that the construction of larger sizes of Venturi flumes than were tested in the laboratory will be encouraged thereby and that they can be calibrated. It is not probable that the last word has been said on the design of the Venturi flume, for, although it has considerable promise, changes in details may prove to be necessary. The laboratory and field tests made thus far have failed to develop any serious inherent defects in the device.

Experiments made in the hydraulic laboratory at Fort Collins, Colorado,on measuring devices led to the development of the so-called Venturi flume during the season of 1915. It consists essentially of a flume with a converging and a diverging section and short "throat" section between them. The floor, which is level, is placed at the elevation of the bottom of the channel in which it is set. After many experiments had been made with different forms and shapes. Venturi flumes with rectangular and trapezoidal cross sections no doubt will be the most used, but the other types were designed to meet special conditions where small flows must be measured.

The action of this device depends upon an adaptation or extension of Venturis principle to the flow of a liquid in an open channel. As water passes through the flume there is a slight surface slope in the converging section, a rather sudden depression in the "throat" section, and a rise in the diverging section. The actual loss of head is small. The determination of the flow depends upon the velocity and wetted cross-sectional area at two points in the -flume, and two gage readings, therefore, are necessary. One gage has been arbitrarily located upstream from the throat a distance equal to two-thirds the length of the converging section, to avoid possible influence due to contraction currents nearer the entrance to the flume; and the other gage has been located at the middle of the throat section, in order to obtain the greatest possible difference in elevation of water surface. The zero of these gages must be at the elevation of the floor of the flume, and it is especially important that the zero of the gages be at exactly the same elevation.

Still boxes, or gage wells, are necessary for accurate readings of the water levels, because of the comparatively high velocity of the water flowing through the structure. Field tests on small Venturi flumes indicated that readings taken to the nearest foot on staff gages placed at the proper locations inside the flume, with the face of the gages countersunk flush with the surface of the side of the flume, would give an accuracy of measurement sufficient for general purposes. This would overcome the necessity for using gage wells, but recent tests made in the laboratory show that such staff-gage readings do not agree with readings taken in the gage wells when there is enough fall in the carrying channel to give a high velocity of flow through the flume, in which case Hd is a considerable amount. Until more is known of the accuracy of gages under different arrangements, caution should be used.

Instrument makers are at work on an automatic register to make graphs of the water elevations at the two gages, both records to appear on a single sheet. An integrating register would be most desirable, but the complexity of the law of flow through the flume certainly would require a complicated instrument.

The effect of the velocity of approach is automatically cared for in the device, and the formula takes account of the velocity of the water at each gage. The experiments indicate that the Venturi flume will be free from interference due to changes in the canal section, such as occur often from sand or silt accumulations or aquatic growths. Such obstructions make the use of the ordinary rating flume very troublesome, if not quite impossible, but these obstructions result only in changing the relative gage readings of the Venturi flume without altering the calibration of the device. Since the velocity increases throughout the converging section, all material carried into the flume also will be carried out, and this self-cleaning feature is of considerable practical importance. When the depth of water is low, floating trash might lodge in the throat of the V-notch Venturi flume, which is of small cross section, but it would cause an accumulation of water in the upstream channel until the wetted cross section at the throat would be sufficient to allow the obstruction to pass. It must be borne in mind that a Venturi flume of whatever form must not be placed below canal grade, for this would give a standing-water condition which would alter the calibration of the device, and it would also allow sand and silt to accumulate within the structure at low velocities. It is important also that the width of the channel of approach be not greatly in excess of the greatest width of the flume, as this permits a silt bank to be deposited at either side wing of the flume. Another practical

feature in connection with the Venturi flume is the small loss of head required for purposes of measuring the flow. Table I shows for the V-notch flume the lost head for the different discharges obtained with different depths of water. The head at the upstream gage is called H_af the head at the throat gage is called H_bt and the difference between these heads (H_a - H_b) is called H. Under usual conditions of operation the lost head will be negligible.

1.3 Advantages and Disadvantages of Parshall flume

The Parshall flume is the best known and most widely used primary device for monitoring water in open channels and non-full pipes. It is used to measure municipal sewage, industrial

Figure 1.2: Venturi Flume

effluent, dam seepage, storm water, irrigation / agricultural flows, watersheds, and more.

1.3.1 Advantages

- Wide range of sizes from 1-inch to 600-inch to handle most flows.
- Can be factory built or formed on site

Suitable above grade and below grade applications

- Integrated flume stands.
- Flume enclosures.
- Curved flume end adapters into existing manholes / vaults.
- Factory integrated in Packaged Metering Manholes.

Most commonly used flume type in North America

- Little to no operator training required.
- Short-throated flume.

Single point of measurement

- Supported by all major open channel flow meter manufacturers
- National and international dimensional / operational standards

- 90 years of research and practical application experience

Available in a range of materials to suit most budgets and application needs

- Aluminum lightweight and durable
- Fiberglass tight dimensional tolerances, lightweight, corrosion resistant
- Galvanized steel - durable and low cost
- Stainless steel - high resistance to corrosion and abrasion, extremely durable

Modified layouts available

- USGS Portable Parshall (discharge section removed)
- Montana (throat and discharge sections removed)

Shortened and extended sidewalls

- Nested configurations for plant expansions, subdivision build-outs, and seasonal flows
- Available with end adapters to monitoring of piped flows
- Extensive array of accessories and options to accommodate most site needs
- Suitable for portable or permanent installations

1.3.2 Disadvantages

If you have any familiarity with managing and measuring flow, then you probably already know that the most popular tool for these important jobs is the Parshall flume. Designed for a wide variety of applications, the Parshall flume is the flow management tool on which every operation can depend.

However, despite its track record of reliability, there are some drawbacks to the Parshall flume that you may not be familiar with, which is why it's a good idea to examine the facts about this tool a little more closely. Check out some of the common drawbacks of the Parshall flume so that you can decide if you should install this flow management tool in your system.

1.3.3 Applications

Since its development in 1922 by Dr. Ralph L. Parshall of the U.S. Soil Conservation Service, the Parshall flume has become the most commonly used flume for monitoring industrial and municipal sewage. Initially intended for the measurement of irrigation flows, the TRACOM's Parshall flume is a particular type of venturi flume which constricts the throat of the flume to produce a differential head that is related to the flow rate. The tapered approach section followed by the downward sloping floor of the throat gives the Parshall flume its ability to withstand relatively high degrees of submergence without affecting the flow rate.

In our project we deal with the Design of Venturi Flumes, Check the performance of the Venturi Flumes and Effects of the Side Using Aspect Ratio.
In Chapter-1 is deald with the Introduction Of Flume, Venturi Flumes, Advantages and Disadvantages Of the Flumes.

In Chapter-2 it deals with literature review i.e in this the different Experimentation to be conducted and the results of that are explained

In Chapter-3 it deals with the Calibration Of Coefficient of Discharge Of Venturi-Meter is explained with results.

In Chapter-4 it deals with the Desigh of the Venturi Flumes such as Rectangle, Trapezoidal and V-Shape Venturi Flumes. Plan and Sections of the Venturi Flumes are drawed using Auto Cad.

In Chapter-5 The Experimentation on Venturi Flumes, plotted the Graphs Between the Depth of water and Discharge And get the Discharge Equations From the Graphs

In Chapter -6 Determination Of the Side Wall Effects using The Aspect Ratio and Froude's number.

In Chapter -7 Results and Discussions on Venturi Flumes is explined.

In Chapter -8 the Conclusions of Venturi Flumes is explined.

Chapter 2

Literature Review

TONY L. WHAL (July 28 to August 1, 2002)

Performance Limits of Width-Contracted Flumes In this paper, a series of flumes having similar geometry but different throat length to width ratios was tested to determine operational limits of width-contracted flumes. It was found that, the modular limits of the widest flumes were found to be lower than the values predicted by theory. In this paper also the guidelines for design of width-contracted flumes are provided.

MUSTAFA GOGUS ISSAM A.AL-KHATIB,AHMET E.ATALAY (2013)

Effect of the Downstream Transition Region of a Flow Measurement flume of Rectangular Compound Cross Section on Flow Properties In this paper, different models are tested to determine the effect of the downstream transition region. For this, values of discharge coefficient, approach velocity and modular limit are studied. These quantities are then related to obtain set of curves to decide which type of downstream transition region would produce highest modular limit.

WILLI H. HAGER(1989 115 (5): 913-913)

Venturi Flume of Minimum Space Requirements: The main aim of this paper is to present a modified Venturi-type discharge measuring structure for large rectangular ducts. A particular attention is given to head discharge equation for different contraction rates, the limit submergence and internal flow mechanism. At the end of study, a new discharge measurement device, which consists of abrupt reduction of channel width presented. This is suitable for mobile use in large rectangular ducts in sewage system.

SAMAD EMAMGHOLIZAISDESH AND KAZEM ASSARE (2008;3(2): 6270.)

Investigation of the Upstream and Downstream Slope of the Long-throated Flumes on the Discharge Coefficient: In this study, a series of experiments were carried out in a flow measurement flume of rectangular cross section. Discharge coefficient of long-throated depends on different parameters such as upstream and downstream slope, step height and throat length. The study showed that the decreasing the upstream slope leads to the increasing the discharge coefficient and when the downstream slope is increased the discharge coefficient of flume increases.

TOM GILL ROBERT EINHELLING (October 26-29, 2005)

Submerged Venturi Flume: The lack of available head has been a constraint limiting the ability to measure flow using traditional critical flow measuring devices. This paper examines a structural alternative for measuring flow under any degree of submergence. First option given is installation of two independent water level sensors. Second option is use of two independent sensors and third is to utilize pressure sensor like Bubbles sensor.

Chapter 3

Calibration Of Coefficient of Discharge Of Venturi-Meter

3.1 Data of Venturi Meter

A Venturi-meter is a device used to measure the fluid flow through pipes. This flow measurement device is based on the principle of Bernoulli's equation. Inside the pipe , pressure difference is created by reducing the cross-sectional area of the flow passage.This difference in pressure is measured with the help of manometer and helps in determining rate of fluid flow or other discharge from the pipe line. As the main inlet area is more as compared to throat , velocity of fluid at throat increases therefore pressure decreases . By this, a pressure difference is created between the inlet and the throat of the venturi-meter. Hence, by reducing the cross-sectional area of the flow passage, a pressure difference is created and we measure that difference in pressure by using Bernoulli equation and discharge formula .

3.2 Procedure

- Set the manometer pressure to the atmospheric pressure by opening the upper valve.
- Now start the supply at water controlled by the stop valve.
- One of the valves of any one of the pipe open and close all other of three.
- Take the discharge reading for the particular flow.
- Take the reading for the pressure head on from the u-tube manometer for corresponding reading of discharge.

- Now take three readings for this pipe and calculate the Cd for that instrument using formula.
- Now close the valve and open valve of other diameter pipe and take the three reading for this.
- Similarly take the reading for all other diameter pipe and calculate Cd for each.

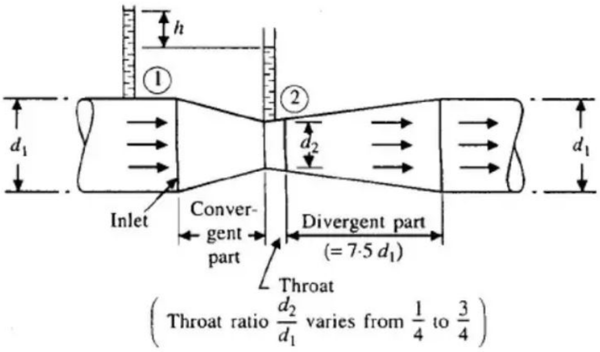


Figure 3.1: Venturi Meter

Diameter of inlet(d) = 49.8mm =0.0498m and outlet(D) =29mm = 0.029m

Area of inlet and Outlet =3.141d^2/4

Area of inlet and Outlet =1.947x10^{-3} m^2 and 6.6052x10^{-4} m^2

Specific Gravity Of Water S_w=1 : Specific Gravity Of Mercury S_m =13.6

Area of collecting tank =0.5x0.5 =0.25m^2

Figure 3.2: Inlet Diameter of Venturi-Meter

3.3 Specifications of Hydraulic Tilting flume

Figure 3.3: Hydraulic Tilting Flume

Slope = +(or)-2% : Width = 0.30m : Length = 6.00m : Height = 0.60m

Dimensions of the Collecting Tank = 0.5m x 0.5m

Figure 3.4: Collecting tank

Table 3.1: Calibration Of Coefficient of Discharge Of Venturi-Meter

S.No	Manometer Readings		Difference Between Two Limbs	Pressure Head H(m)	Time For R m Rise	Q_{act} (m^3/sec)	Q_{th} (m^3/sec)	Coefficient of Discharge
	Left Limb h_1 (m)	Right Limb h_2(m)	X=(h_2-h_1) (m)	H=X{(S_m /S_w)-1}	R= 0.1m t Sec	A_cR/t	A_1.A_2SQRT(2 gH)/SQRT{(A_1)^2-(A_2)^2}	C_d= Q_{act}/ Q_{th}
1	0.175	0.188	0.013	0.164	18.720	0.00134	0.00126	1.06099991
2	0.168	0.195	0.027	0.340	12.750	0.00196	0.00181	1.08093804
3	0.161	0.201	0.040	0.504	10.330	0.00242	0.00221	1.09613123
4	0.153	0.210	0.057	0.718	8.840	0.00283	0.00264	1.07300853
5	0.146	0.216	0.070	0.882	7.955	0.00314	0.00292	1.07597868
							Average =	1.07741128

3.3.1 Results

- The Coefficient of Discharge Of Venturi-Meter C_d is 1.077

Chapter 4

Design of Venturi Flumes

Scope

This International Standard specifies methods for the measurement of flow in rivers and artificial channels under steady or slowly varying flow conditions, using certain types of standing-wave, or critical-depth, flumes. A wide variety of flumes has been developed, but only those which have received general acceptance after adequate research and field testing, and which therefore do not require in situ calibration, are considered.

The flow conditions considered are uniquely dependent on the upstream head, i.e. subcritical flow must exist upstream of the flume, after which the flow accelerates through the contraction and passes through its critical depth. The water level downstream of the structure is low enough to have no influence upon its performance.

This International Standard is applicable to three commonly used types of flumes, covering a wide range of applications, namely rectangular-throated, trapezoidal-throated and U-throated. Typical field installations. Site conditions are important and acceptable velocity profiles in the approach channel.

The rectangular-throated flume is the simplest to construct. It generally proves necessary to raise the invert of the flume throat above the bed of the channel upstream, in order to generate a constriction that is sufficiently severe to allow low flows to be gauged. However, this may result in a regime of cyclic sediment accretion and erosion upstream, which would affect the accuracy and consistency of gauging.

In this Fabrication of venturi flumes using the **Wood Material**

4.1 Design of Rectangular Venturi Flume

The breadth of throat is equal to 101 mm, which corresponds to the lower limit of the domain of validity of ISO 4359:2012.

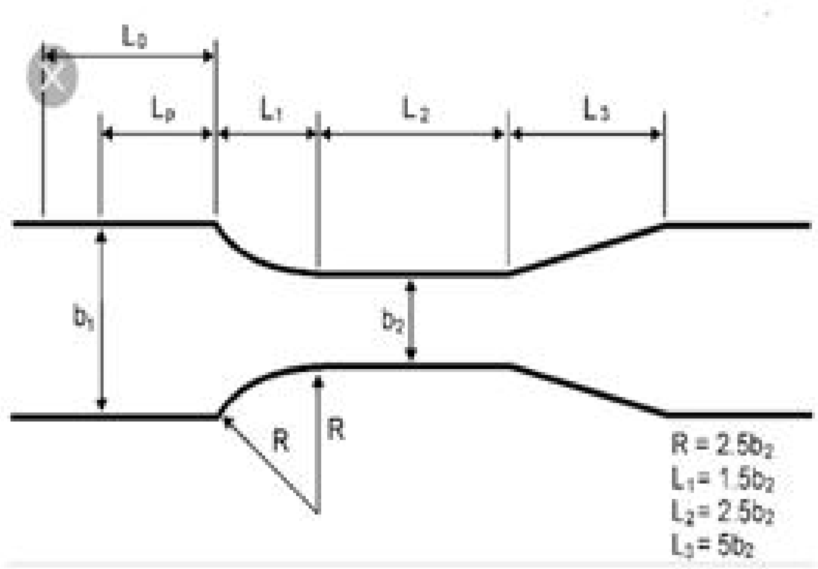


Figure 4.1: Design of Rectangular Venturi Flume

L_1=1.5b_2 =151.2 mm : L_2 =2.5 b_2 =252.5 mm

L_3 =5b_2 = 505 mm : R=2.5 b_2 =252.5 mm

Cross Sectional Area of Rectangular Venturi Flume at Throat A_{Rec} = 151.5 mm^2

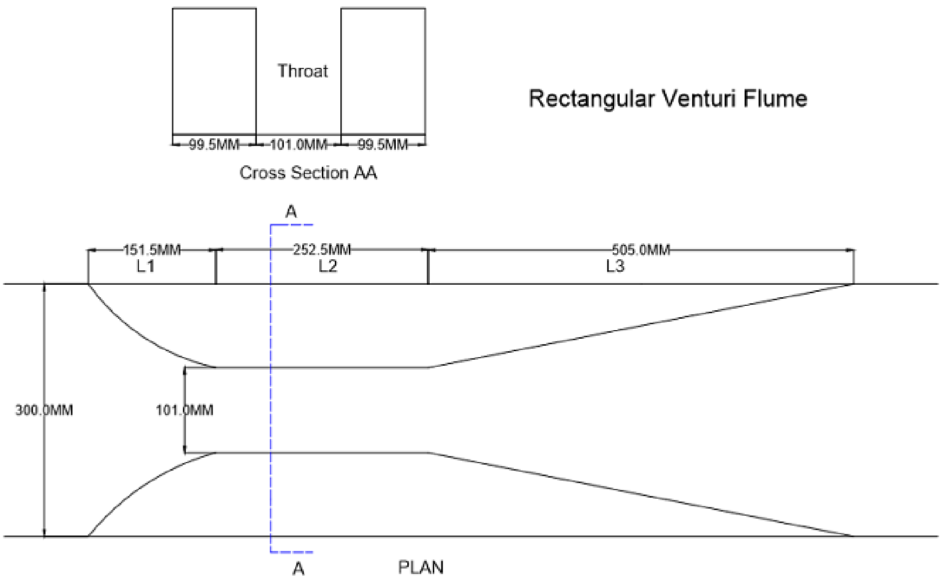


Figure 4.2: Design of Rectangular Venturi Flume

4.2 Design of Trapezoidal Venturi Flume

In this Design we considered the constant Area and Depth of Rectangle Venturi flume. To check the performance of the Venturi Flumes on the basis we designed the Trapezoidal Venturi Flume and V- Shaped Venturi Flume

Trapezoidal Venturi Flume sectional dimensions are shown in figure(4.3) Cross Sectional Area of the Trapezoidal Venturi Flume at Throat A_{Tre} = (B+nd)d = (63.5 + 0.25 x 150) x 150 A_{Tre} = 151.5 mm^2

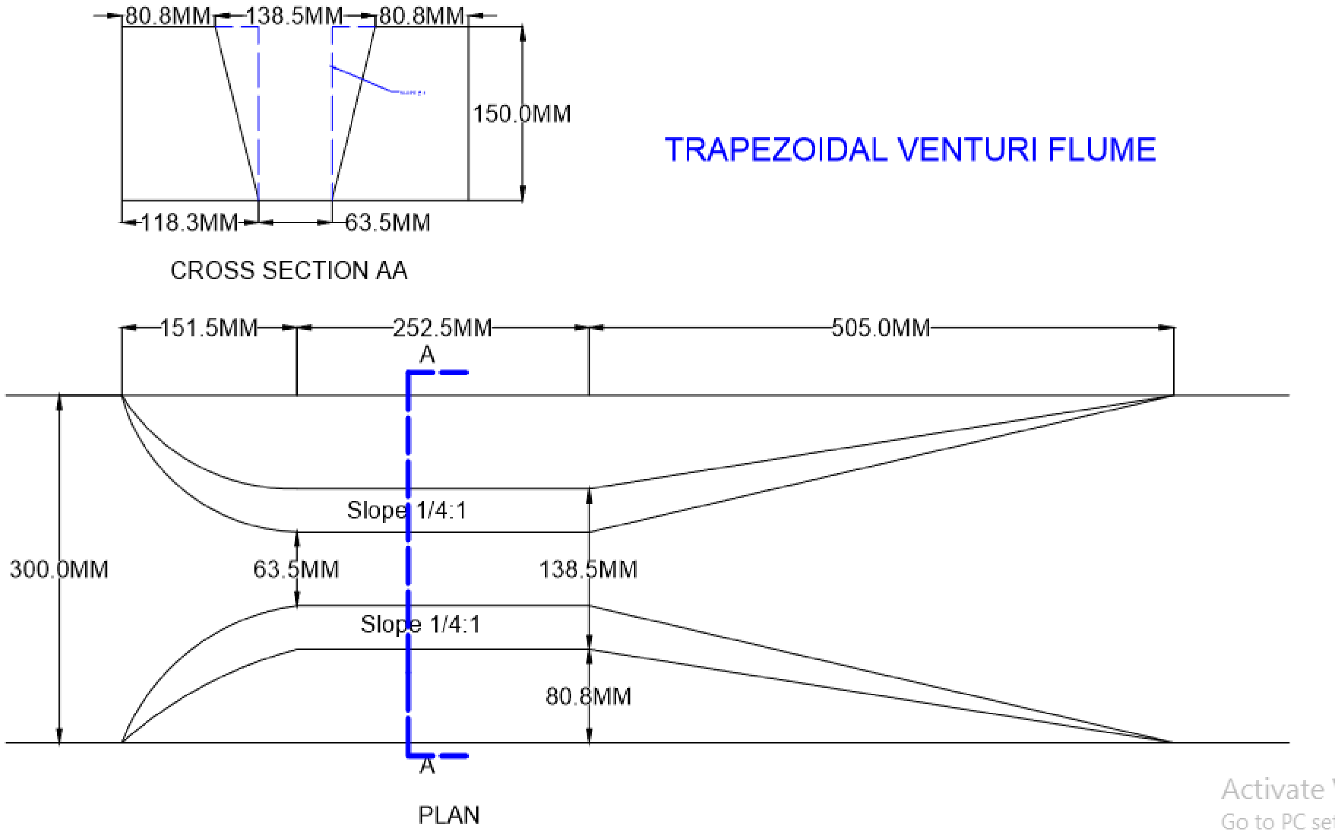


Figure 4.3: Design of Trapezoidal Venturi Flume

4.3 Design of V-Shape Venturi Flume

V-Shape Venturi Flume sectional dimensions are shown in figure(4.4) Cross Sectional Area of the V-Shape Venturi Flume at Throat A_V = 151.5 mm^2

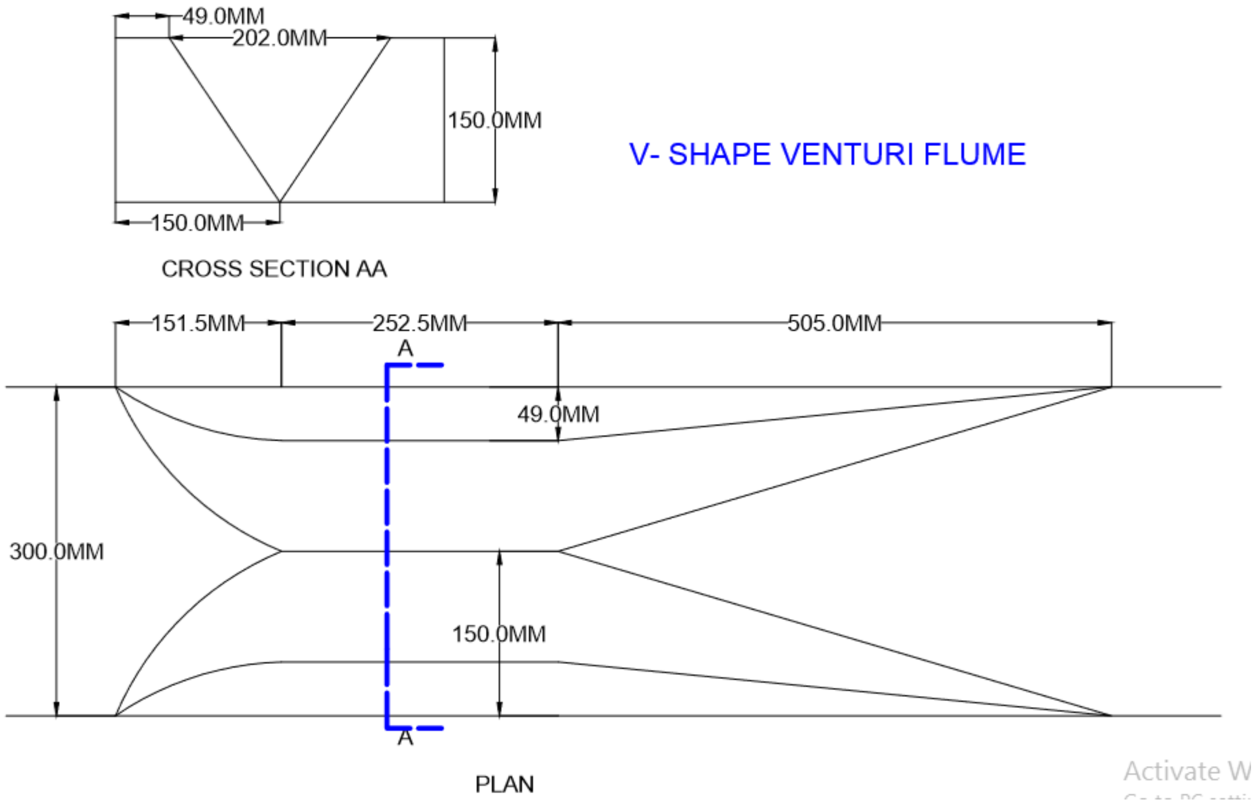


Figure 4.4: Design of V-Shape Venturi Flume

4.4 Intervals

We Measures the Water depths (h) by using Point Gauge at various Intervals. The Intervals are shown in figure(4.5)

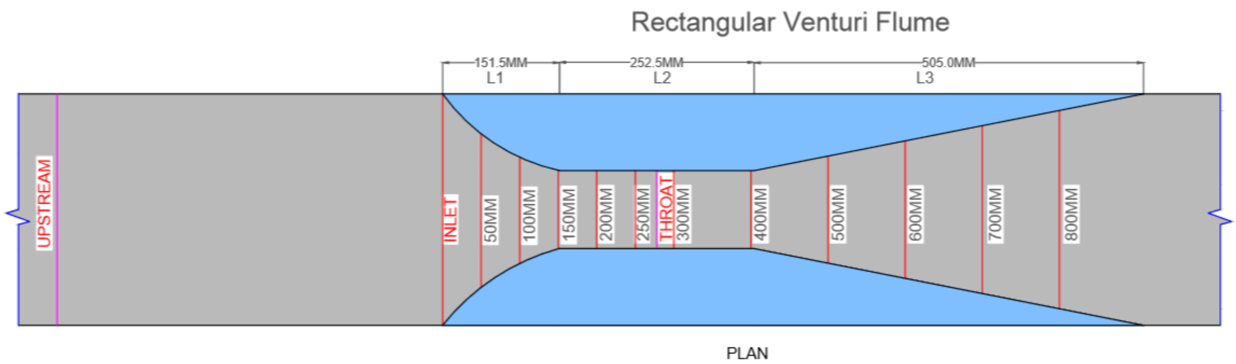


Figure 4.5: Rectangular Venturi Flumes Intervals

Chapter 5

Experimentation On Venturi Flumes

5.1 Experiments On Rectangle Venturi Flumes

5.1.1 Experiment-1

- **In this Experiment Slope is Maintained by Flat. (S_0=Flat)**

Top View of Rectangular Venturi Flume

Front View of Rectangular Venturi Flume

Figure 5.1: Model Of Rectangle Venturi Flume

Table 5.1: Discharge and Depth Of Water Flow in Rectangular Venturi Flume

Manometer Readings (m)		Difference between two Limbs (m)	Pressure Head	Inlet Area (m^2)	Throat Area (m^2)	Discharge (m^3/sec)	Discharge (Lit/sec)	Depth Of Water Flow in Rectangular Venturi Flume (m)	
h_1	h_2	X_m	H	A_1	A_2	Q	Q	Upstream	Throat
0.298	0.068	0.230	2.898	0.001948	0.000661	0.005665	5.6649	0.111	0.070
0.276	0.089	0.187	2.356	0.001948	0.000661	0.005108	5.1080	0.104	0.065
0.263	0.103	0.160	2.016	0.001948	0.000661	0.004725	4.7249	0.098	0.062
0.252	0.111	0.141	1.777	0.001948	0.000661	0.004435	4.4355	0.095	0.060
0.240	0.123	0.117	1.474	0.001948	0.000661	0.004040	4.0404	0.088	0.055
0.224	0.139	0.085	1.071	0.001948	0.000661	0.003444	3.4438	0.078	0.050
0.208	0.153	0.055	0.693	0.001948	0.000661	0.002770	2.7702	0.069	0.044
0.197	0.166	0.031	0.391	0.001948	0.000661	0.002080	2.0798	0.058	0.037

Table 5.2: Discharge and Depth

(Upstream - Throat) Depth in (m)	**Average Depth (U+T/2 in (m)**	**Discharge in (m^3/sec)**
X	**X**	**Y**
0.041	0.0905	0.0056649
0.039	0.0845	0.005108
0.036	0.08	0.0047249
0.035	0.0775	0.0044355
0.0327	0.07165	0.0040404
0.028	0.0643	0.00344328
0.0254	0.0563	0.0027702
0.021	0.0475	0.0020798

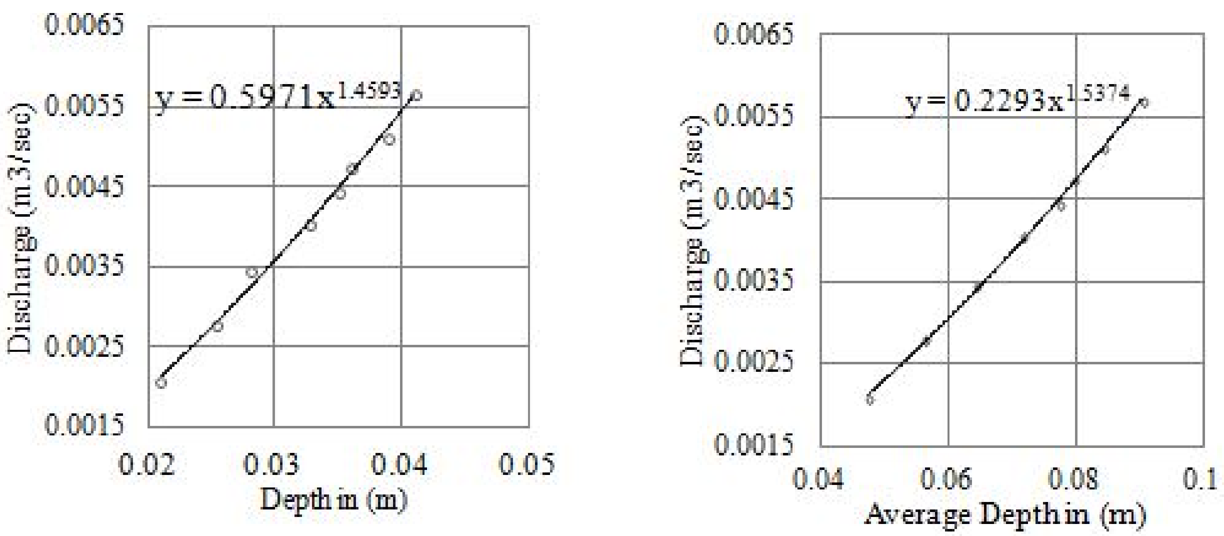


Figure 5.2: Graph Between The Depth and Discharge

Profile of Water Flow

Table 5.3: Depth Of Water Flow in Rectangular Venturi Flume Certain Intervals

Intervals in (m)	**Y_1 Depth in (m)**	**Y_2 Depth in (m)**	**Y_3 Depth in (m)**	**Y_4 Depth in (m)**	**Y_5 Depth in (m)**	**Y_6 Depth in (m)**	**Y_7 Depth in (m)**	**Y_8 Depth in (m)**
0	0.111	0.104	0.098	0.095	0.089	0.0805	0.0695	0.058
0.05	0.1093	0.102	0.097	0.094	0.0882	0.079	0.069	0.057
0.1	0.105	0.099	0.094	0.091	0.084	0.076	0.066	0.055
0.15	0.096	0.09	0.084	0.081	0.076	0.069	0.0586	0.048
0.2	0.084	0.075	0.072	0.068	0.063	0.056	0.0475	0.0392
0.25	0.072	0.067	0.064	0.061	0.057	0.051	0.0442	0.0372
0.3	0.068	0.064	0.061	0.059	0.0543	0.05	0.0433	0.038
0.4	0.062	0.059	0.056	0.054	0.052	0.048	0.043	0.038
0.5	0.041	0.039	0.038	0.035	0.033	0.031	0.0273	0.0232
0.6	0.03	0.0295	0.028	0.027	0.024	0.022	0.0203	0.0166
0.7	0.023	0.022	0.021	0.019	0.019	0.0175	0.015	0.013
0.8	0.018	0.018	0.017	0.016	0.0153	0.014	0.013	0.012

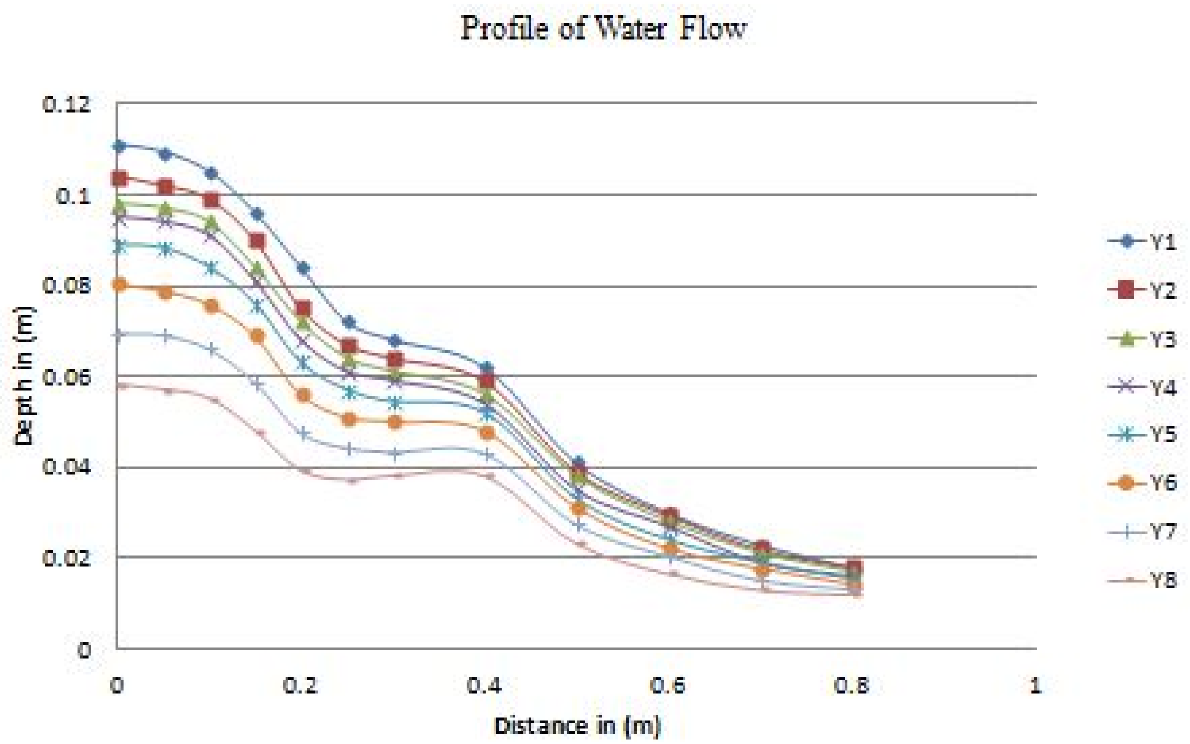


Figure 5.3: Profile of Water Flow in Rectangular Venturi Flume

5.1.2 Experiment-2

- **In this Experiment Slope is Maintained by 1 in 160. (S_0= 25mm)**

Table 5.4: Discharge and Depth Of Water Flow in Rectangular Venturi Flume

Manometer Readings (m)		Difference between two Limbs (m)	Pressure Head	Inlet Area (m^2)	Throat Area (m^2)	Discharge (m^3/sec)	Discharge (Lit/sec)	Depth Of Water Flow in Rectangular Venturi Flume (m)	
h_1	h_2	X_m	H	A_1	A_2	Q	Q	Upstream	Throat
0.298	0.068	0.230	2.898	0.001948	0.000661	0.005665	5.6649	0.108	0.071
0.275	0.090	0.185	2.331	0.001948	0.000661	0.005081	5.0806	0.101	0.066
0.262	0.101	0.161	2.029	0.001948	0.000661	0.004740	4.7396	0.096	0.063
0.249	0.114	0.135	1.701	0.001948	0.000661	0.004340	4.3401	0.091	0.059
0.238	0.124	0.114	1.436	0.001948	0.000661	0.003988	3.9883	0.085	0.056
0.226	0.136	0.090	1.134	0.001948	0.000661	0.003544	3.5437	0.078	0.052
0.208	0.153	0.055	0.693	0.001948	0.000661	0.002770	2.7702	0.066	0.043
0.198	0.163	0.035	0.441	0.001948	0.000661	0.002210	2.2099	0.057	0.038

Table 5.5: Discharge and Depth

(Upstream - Throat) Depth in (m)	**Average Depth (U+T/2 in (m)**	**Discharge in (m^3/sec)**
X	**X**	**Y**
0.0367	0.0897	0.005665
0.0354	0.0833	0.005081
0.0334	0.0793	0.004740
0.0319	0.0751	0.004340
0.0292	0.0707	0.003988
0.0260	0.0650	0.003544
0.0230	0.0545	0.002770
0.0195	0.0473	0.002210

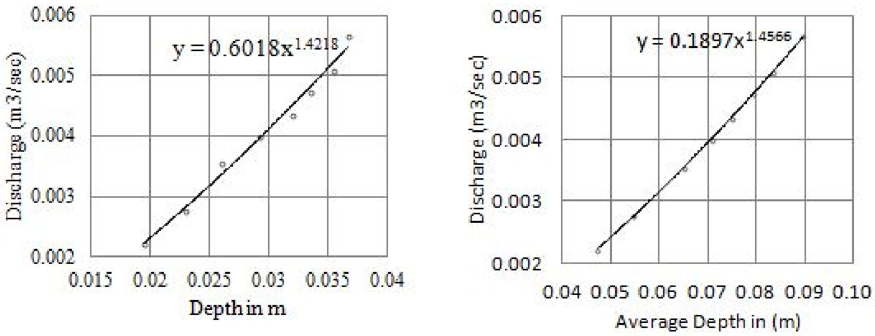


Figure 5.4: Graph Between The Depth and Discharge

Profile of Water Flow

Table 5.6: Depth Of Water Flow in Rectangular Venturi Flume Certain Intervals

Intervals in (m)	**Y_1 Depth in (m)**	**Y_2 Depth in (m)**	**Y_3 Depth in (m)**	**Y_4 Depth in (m)**	**Y_5 Depth in (m)**	**Y_6 Depth in (m)**	**Y_7 Depth in (m)**	**Y_8 Depth in (m)**
0	0.112	0.105	0.100	0.095	0.089	0.083	0.070	0.060
0.05	0.110	0.103	0.099	0.094	0.089	0.081	0.069	0.059
0.1	0.107	0.101	0.096	0.090	0.086	0.079	0.067	0.055
0.15	0.097	0.091	0.086	0.083	0.078	0.071	0.065	0.054
0.2	0.083	0.076	0.073	0.068	0.065	0.058	0.052	0.043
0.25	0.074	0.068	0.065	0.061	0.058	0.053	0.048	0.041
0.3	0.070	0.064	0.061	0.058	0.055	0.051	0.047	0.040
0.4	0.063	0.058	0.057	0.054	0.052	0.049	0.046	0.038
0.5	0.041	0.037	0.037	0.035	0.033	0.031	0.029	0.024
0.6	0.032	0.030	0.027	0.026	0.024	0.023	0.022	0.016
0.7	0.022	0.021	0.020	0.018	0.017	0.016	0.016	0.014
0.8	0.017	0.017	0.016	0.015	0.015	0.014	0.013	0.012

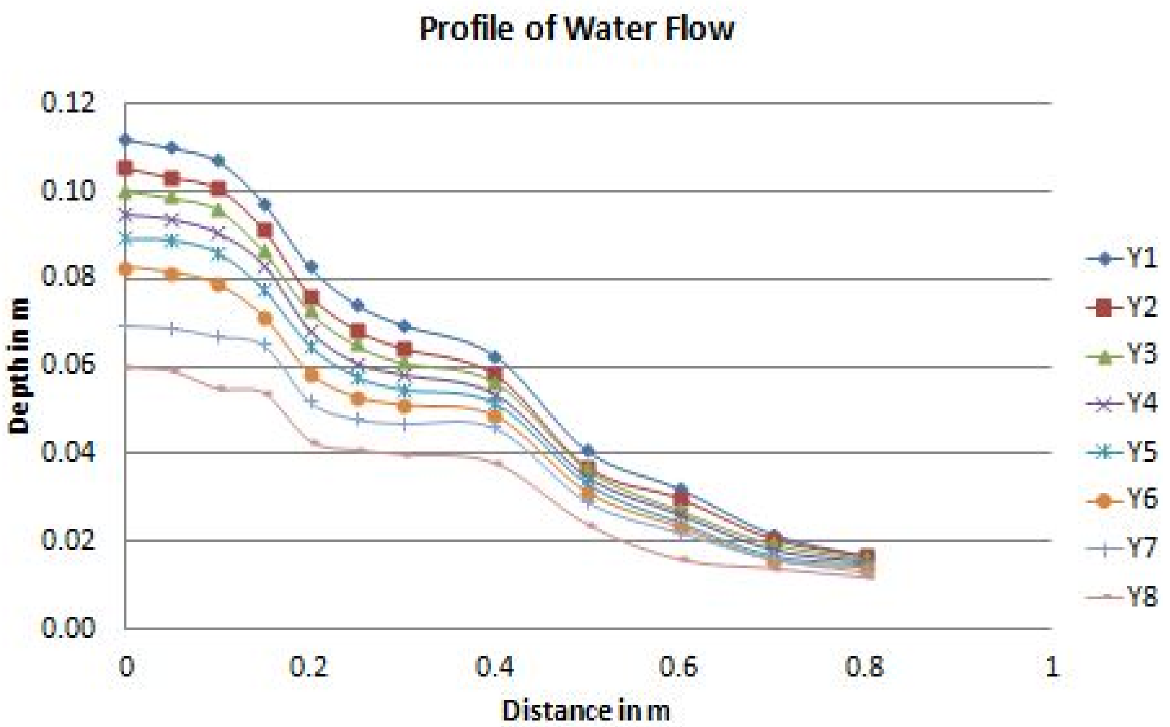


Figure 5.5: Profile of Water Flow in Rectangular Venturi Flume

5.1.3 Experiment-3

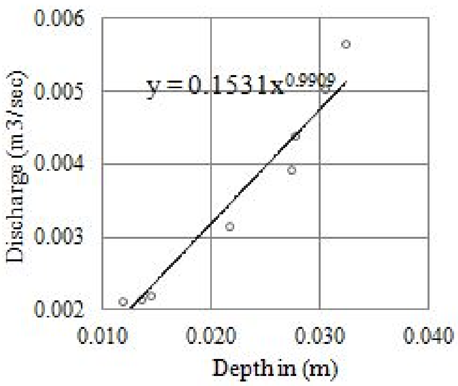
- **In this Experiment Slope is Maintained by 1 IN 80. (S_0= 50mm)**

Table 5.7: Discharge and Depth Of Water Flow in Rectangular Venturi Flume

Manometer Readings (m)		Difference between two Limbs (m)	Pressure Head	Inlet Area (m^2)	Throat Area (m^2)	Discharge (m^3/sec)	Discharge (Lit/sec)	Depth Of Water Flow in Rectangular Venturi Flume (m)	
h_1	h_2	X_m	H	A_1	A_2	Q	Q	Upstream	Throat
0.298	0.068	0.230	2.898	0.001948	0.000661	0.005665	5.6649	0.104	0.072
0.273	0.091	0.182	2.293	0.001948	0.000661	0.005039	5.0393	0.096	0.065
0.251	0.112	0.139	1.751	0.001948	0.000661	0.004404	4.4039	0.087	0.059
0.236	0.126	0.110	1.386	0.001948	0.000661	0.003918	3.9177	0.080	0.053
0.216	0.145	0.071	0.895	0.001948	0.000661	0.003147	3.1475	0.070	0.048
0.203	0.168	0.035	0.441	0.001948	0.000661	0.002210	2.2099	0.055	0.041
0.196	0.163	0.033	0.416	0.001948	0.000661	0.002146	2.1458	0.049	0.035
0.191	0.159	0.032	0.403	0.001948	0.000661	0.002113	2.1130	0.042	0.030

Table 5.8: Discharge and Depth

(Upstream - Throat) Depth in (m)	**Average Depth (U+T/2 in (m)**	**Discharge in (m^3/sec)**
X	**X**	**Y**
0.0324	0.0878	0.005665
0.0304	0.08038	0.005039
0.0277	0.07295	0.004404
0.0274	0.0663	0.003918
0.0217	0.05915	0.003147
0.0145	0.04775	0.002210
0.0137	0.04215	0.002146
0.0120	0.036	0.002113



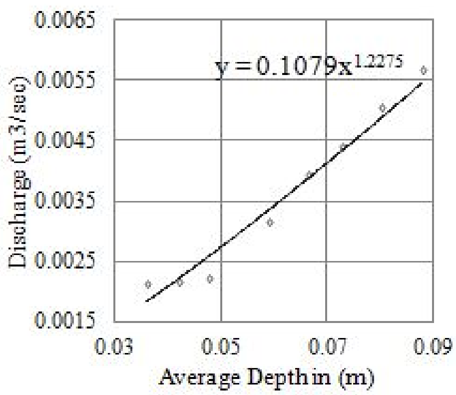


Figure 5.6: Graph Between The Depth and Discharge

Profile of Water Flow

Table 5.9: Depth Of Water Flow in Rectangular Venturi Flume Certain Intervals

Intervals in (m)	**Y_1 Depth in (m)**	**Y_2 Depth in (m)**	**Y_3 Depth in (m)**	**Y_4 Depth in (m)**	**Y_5 Depth in (m)**	**Y_6 Depth in (m)**	**Y_7 Depth in (m)**	**Y_8 Depth in (m)**
0	0.1113	0.1040	0.0941	0.0875	0.0765	0.0640	0.0565	0.0485
0.05	0.110	0.103	0.093	0.0870	0.0760	0.0635	0.0560	0.0475
0.1	0.107	0.0993	0.0906	0.0846	0.0740	0.0616	0.0545	0.0416
0.15	0.0976	0.0906	0.0833	0.0770	0.0676	0.0550	0.0475	0.0410
0.2	0.0826	0.0756	0.0665	0.0625	0.0560	0.0461	0.0400	0.0340
0.25	0.0745	0.0683	0.0600	0.0583	0.0490	0.0410	0.0380	0.0320
0.3	0.0676	0.0643	0.0580	0.0536	0.0470	0.0400	0.0345	0.0305
0.4	0.0621	0.0570	0.0538	0.0511	0.0450	0.0390	0.0340	0.0300
0.5	0.0403	0.0370	0.0343	0.0320	0.0291	0.0246	0.0216	0.0205
0.6	0.0333	0.0290	0.0266	0.0243	0.0220	0.0180	0.0150	0.0143
0.7	0.0225	0.0200	0.0183	0.0163	0.0160	0.0133	0.0120	0.0105
0.8	0.0155	0.0150	0.0150	0.0146	0.0131	0.0130	0.0105	0.0095

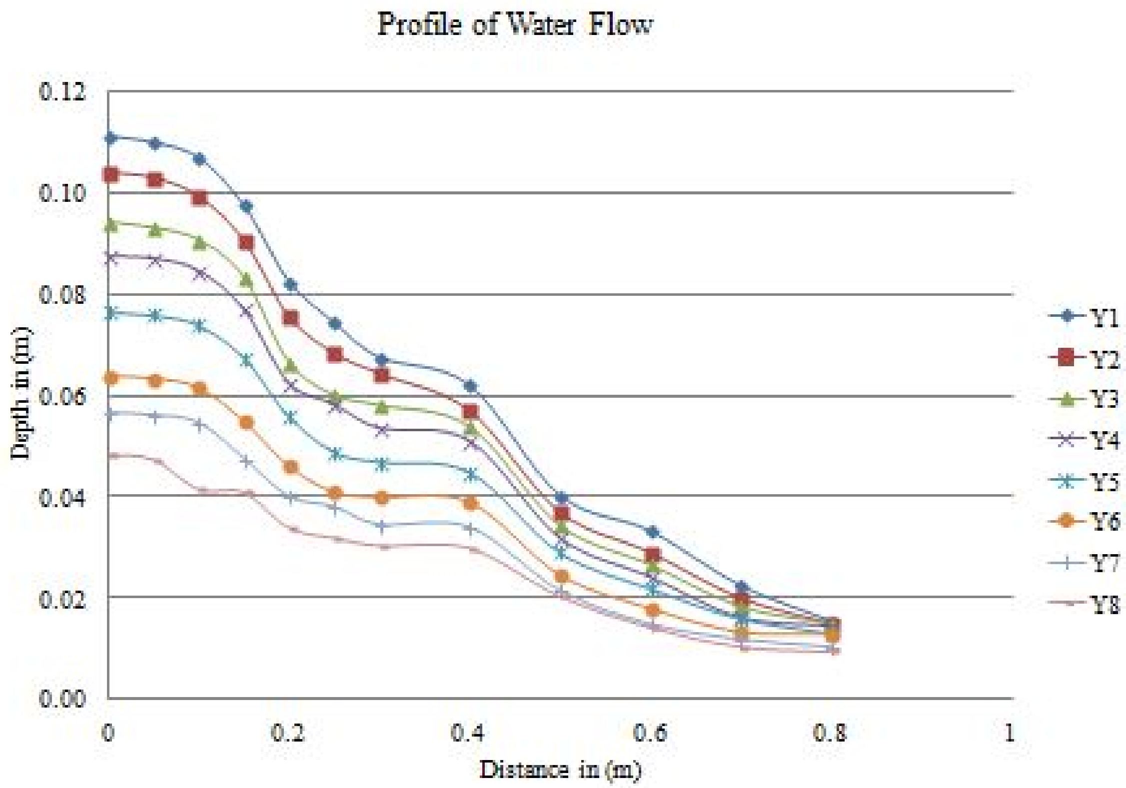
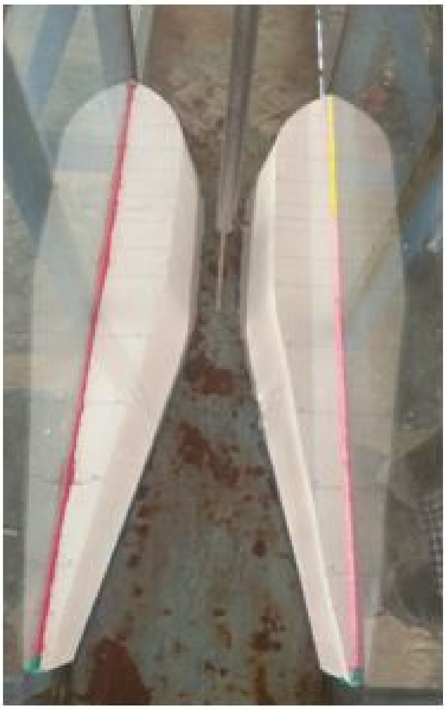


Figure 5.7: Profile of Water Flow in Rectangular Venturi Flume

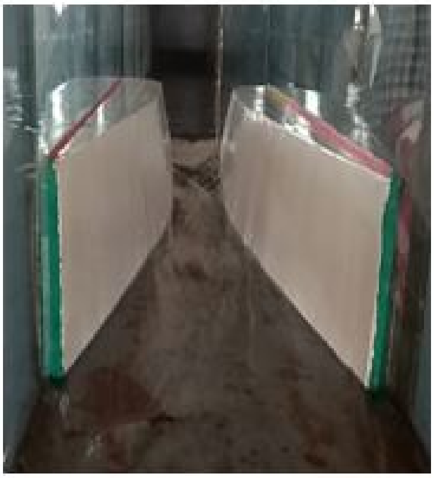
5.2 Experiments On Trapezoidal Venturi Flumes

5.2.1 Experiment-1

- **In this Experiment Slope is Maintained by Flat. (S_0=Flat)**



Top View of Trapezoidal Venturi Flume



Front View of Trapezoidal Venturi Flume

Front View of Trapezoidal Venturi Flume

Figure 5.8: Model Of Trapezoidal Venturi Flume

Table 5.10: Discharge and Depth Of Water Flow in Trapezoidal Venturi Flume

Manometer Readings (m)		Difference between two Limbs (m)	Pressure Head	Inlet Area (m^2)	Throat Area (m^2)	Discharge (m^3/sec)	Discharge (Lit/sec)	Depth Of Water Flow in Trapezoidal Venturi Flume (m)	
h_1	h_2	X_m	H	A_1	A_2	Q	Q	Upstream	Throat
0.293	0.073	0.22	2.772	0.001948	0.000661	0.005540	5.54041	0.122	0.0852
0.283	0.083	0.2	2.520	0.001948	0.000661	0.005283	5.28258	0.119	0.0833
0.266	0.099	0.167	2.104	0.001948	0.000661	0.004827	4.82713	0.113	0.0796
0.252	0.110	0.142	1.789	0.001948	0.000661	0.004451	4.45118	0.108	0.076
0.236	0.125	0.111	1.399	0.001948	0.000661	0.003935	3.93543	0.101	0.0715
0.221	0.141	0.08	1.008	0.001948	0.000661	0.003341	3.34100	0.0925	0.065
0.204	0.157	0.047	0.592	0.001948	0.000661	0.002561	2.56082	0.079	0.0556
0.194	0.166	0.028	0.353	0.001948	0.000661	0.001977	1.97656	0.063	0.0445

Table 5.11: Discharge and Depth

(Upstream - Throat) Depth in (m)	Average Depth (U+T/2 in (m)	Discharge in (m^3/sec)
X	**X**	**Y**
0.0368	0.1036	0.00554
0.0357	0.10115	0.00528
0.0334	0.0963	0.00483
0.0323	0.092	0.00444
0.0295	0.08625	0.00405
0.0275	0.07875	0.00334
0.0234	0.0673	0.00256
0.0185	0.05375	0.00198

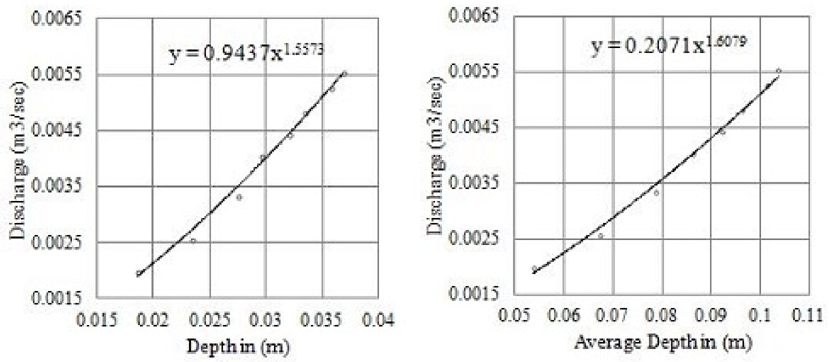


Figure 5.9: Graph Between The Depth and Discharge

Profile of Water Flow

Table 5.12: Depth Of Water Flow in Trapezoidal Venturi Flume Certain Intervals

Intervals in (m)	Y_1 Depth in (m)	Y_2 Depth in (m)	Y_3 Depth in (m)	Y_4 Depth in (m)	Y_5 Depth in (m)	Y_6 Depth in (m)	Y_7 Depth in (m)	Y_8 Depth in (m)
0	0.1220	0.1190	0.1130	0.1086	0.1040	0.0929	0.0796	0.0668
0.05	0.1200	0.1170	0.1113	0.1070	0.1000	0.0913	0.0785	0.0645
0.1	0.1137	0.1107	0.1060	0.1010	0.0950	0.0860	0.0745	0.0601
0.15	0.1050	0.1010	0.0980	0.0935	0.0875	0.0795	0.0675	0.0540
0.2	0.0948	0.0928	0.0883	0.0841	0.0786	0.0726	0.0610	0.0483
0.25	0.0887	0.0868	0.0826	0.0786	0.0733	0.0668	0.0576	0.0462
0.3	0.0837	0.0818	0.0775	0.0736	0.0695	0.0635	0.0546	0.0450
0.4	0.0729	0.0725	0.0680	0.0641	0.0620	0.0560	0.0495	0.0392
0.5	0.0463	0.0455	0.0450	0.0406	0.0390	0.0341	0.0290	0.0227
0.6	0.0322	0.0315	0.0305	0.0286	0.0280	0.0230	0.0200	0.0145
0.7	0.0238	0.0233	0.0220	0.0200	0.0190	0.0170	0.0152	0.0113
0.8	0.0183	0.0178	0.0165	0.0161	0.0148	0.0140	0.0120	0.0099

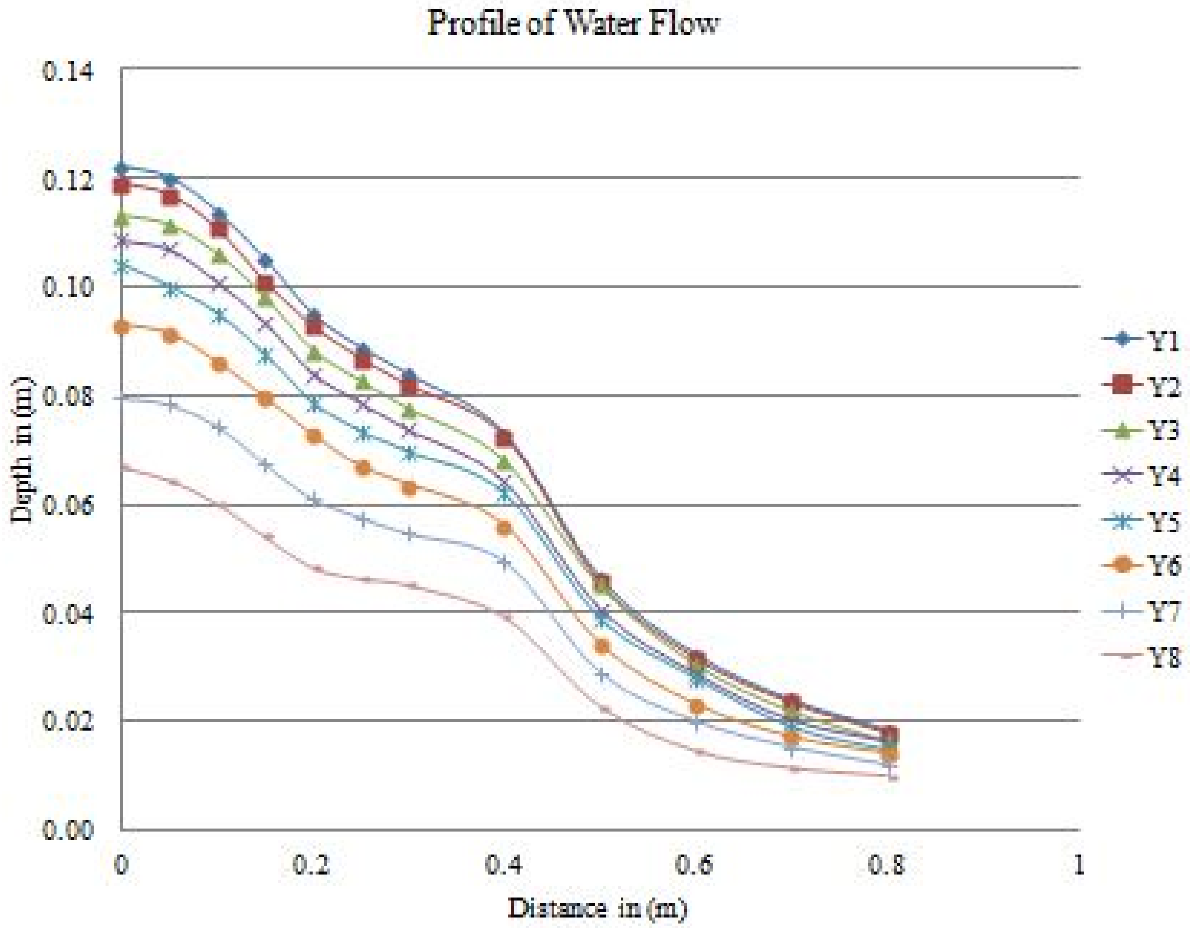


Figure 5.10: Profile of Water Flow in Trapezoidal Venturi Flume

5.2.2 Experiment-2

- **In this Experiment Slope is Maintained by 1 in 160. (S_0= 25mm)**

Table 5.13: Discharge and Depth Of Water Flow in Trapezoidal Venturi Flume

Manometer Readings (m)		Difference between two Limbs (m)	Pressure Head	Inlet Area (m^2)	Throat Area (m^2)	Discharge (m^3/sec)	Discharge (Lit/sec)	Depth Of Water Flow in Trapezoidal Venturi Flume (m)	
h_1	h_2	X_m	H	A_1	A_2	Q	Q	Upstream	Throat
0.288	0.077	0.211	2.659	0.001948	0.000661	0.005426	5.42590	0.1130	0.0813
0.284	0.080	0.204	2.570	0.001948	0.000661	0.005335	5.33514	0.1100	0.0810
0.264	0.099	0.165	2.079	0.001948	0.000661	0.004798	4.79814	0.1040	0.0763
0.252	0.111	0.141	1.777	0.001948	0.000661	0.004435	4.43548	0.0995	0.0735
0.238	0.126	0.112	1.411	0.001948	0.000661	0.003953	3.95312	0.0920	0.0681
0.224	0.138	0.086	1.084	0.001948	0.000661	0.003464	3.46402	0.0860	0.0638
0.209	0.153	0.056	0.706	0.001948	0.000661	0.002795	2.79528	0.0760	0.0560
0.194	0.167	0.027	0.340	0.001948	0.000661	0.001941	1.94094	0.0600	0.0446

Table 5.14: Discharge and Depth

(Upstream - Throat) Depth in (m)	Average Depth (U+T/2 in (m)	Discharge in (m^3/sec)
X	**X**	**Y**
0.0317	0.0972	0.00543
0.0290	0.0955	0.00534
0.0277	0.0902	0.00480
0.0260	0.0865	0.00444
0.0239	0.0801	0.00395
0.0222	0.0749	0.00346
0.0200	0.0660	0.00280
0.0154	0.0523	0.00194

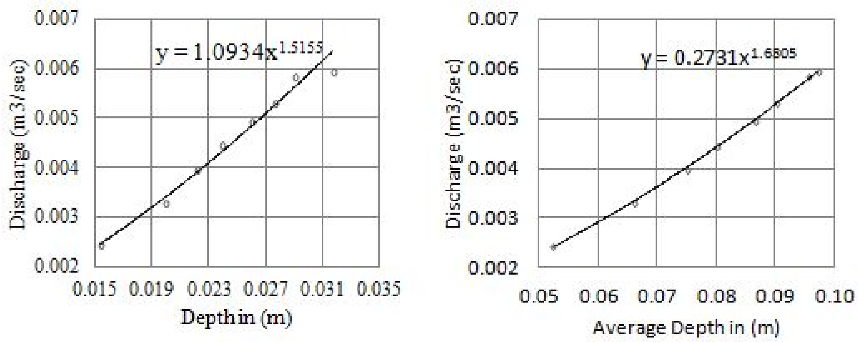


Figure 5.11: Graph Between The Depth and Discharge

Profile of Water Flow

Table 5.15: Depth Of Water Flow in Trapezoidal Venturi Flume Certain Intervals

Intervals in (m)	Y_1 Depth in (m)	Y_2 Depth in (m)	Y_3 Depth in (m)	Y_4 Depth in (m)	Y_5 Depth in (m)	Y_6 Depth in (m)	Y_7 Depth in (m)	Y_8 Depth in (m)
0	0.118	0.116	0.110	0.105	0.099	0.091	0.081	0.065
0.05	0.116	0.113	0.109	0.104	0.098	0.090	0.081	0.064
0.1	0.111	0.109	0.103	0.099	0.093	0.086	0.077	0.061
0.15	0.102	0.099	0.095	0.090	0.084	0.079	0.069	0.055
0.2	0.092	0.090	0.086	0.082	0.077	0.071	0.062	0.050
0.25	0.086	0.084	0.080	0.076	0.070	0.064	0.058	0.046
0.3	0.080	0.078	0.075	0.071	0.063	0.062	0.055	0.044
0.4	0.069	0.067	0.065	0.063	0.059	0.054	0.049	0.037
0.5	0.045	0.043	0.041	0.040	0.038	0.033	0.030	0.024
0.6	0.031	0.030	0.028	0.027	0.026	0.023	0.021	0.016
0.7	0.023	0.023	0.021	0.019	0.017	0.017	0.014	0.012
0.8	0.017	0.016	0.016	0.015	0.013	0.013	0.011	0.009

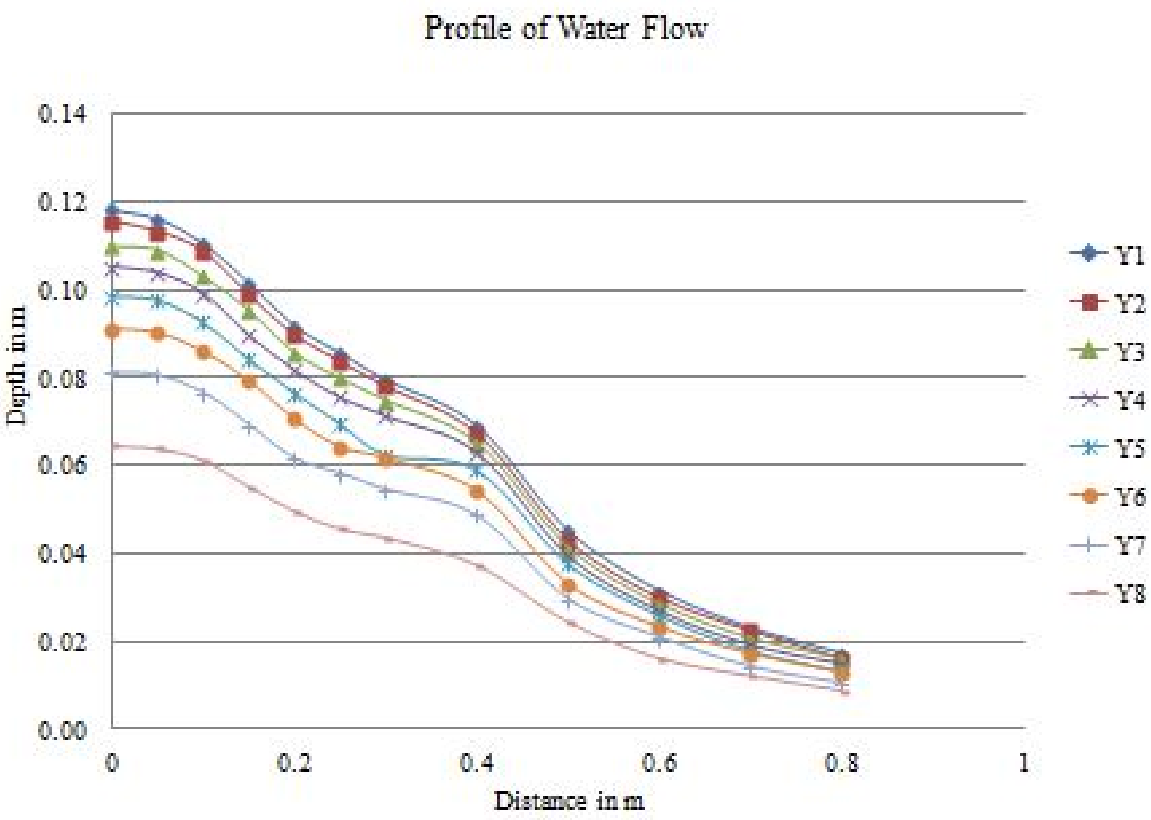


Figure 5.12: Profile of Water Flow in Trapezoidal Venturi Flume

5.2.3 Experiment-3

- **In this Experiment Slope is Maintained by 1 IN 80.** (S_0= 50mm)

Table 5.16: Discharge and Depth Of Water Flow in Trapezoidal Venturi Flume

Manometer Readings (m)		Difference between two Limbs (m)	Pressure Head	Inlet Area (m^2)	Throat Area (m^2)	Discharge (m^3/sec)	Discharge (Lit/sec)	Depth Of Water Flow in Trapezoidal Venturi Flume (m)	
h_1	h_2	X_m	H	A_1	A_2	Q	Q	Upstream	Throat
0.293	0.072	0.221	2.785	0.001948	0.000661	0.005553	5.552992	0.1120	0.0830
0.279	0.085	0.194	2.444	0.001948	0.000661	0.005203	5.202736	0.1070	0.0800
0.268	0.095	0.173	2.180	0.001948	0.000661	0.004913	4.913082	0.1030	0.0766
0.252	0.111	0.141	1.777	0.001948	0.000661	0.004435	4.435478	0.0980	0.0720
0.241	0.121	0.120	1.512	0.001948	0.000661	0.004092	4.091867	0.0930	0.0678
0.227	0.134	0.093	1.172	0.001948	0.000661	0.003602	3.602238	0.0855	0.0635
0.208	0.152	0.056	0.706	0.001948	0.000661	0.002795	2.795278	0.0735	0.0545
0.198	0.162	0.036	0.454	0.001948	0.000661	0.002241	2.241208	0.0630	0.0473

Table 5.17: Discharge and Depth

(Upstream - Throat) Depth in (m)	Average Depth (U+T/2 in (m)	Discharge in (m^3/sec)
X	X	Y
0.02900	0.0975	0.00555
0.02700	0.09350	0.00520
0.02640	0.0898	0.00491
0.02600	0.08500	0.00444
0.02520	0.08040	0.00409
0.02200	0.07450	0.00360
0.01900	0.06400	0.00280
0.01570	0.05515	0.00224

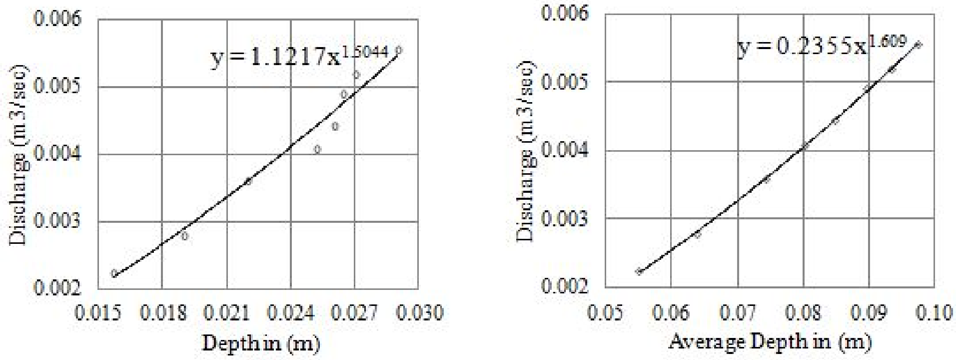


Figure 5.13: Graph Between The Depth and Discharge

Profile of Water Flow

Table 5.18: Depth Of Water Flow in Trapezoidal Venturi Flume Certain Intervals

Intervals in (m)	Y_1 Depth in (m)	Y_2 Depth in (m)	Y_3 Depth in (m)	Y_4 Depth in (m)	Y_5 Depth in (m)	Y_6 Depth in (m)	Y_7 Depth in (m)	Y_8 Depth in (m)
0	0.119	0.114	0.1105	0.1050	0.0995	0.0935	0.0800	0.0690
0.05	0.117	0.113	0.109	0.1030	0.0986	0.0926	0.0796	0.0685
0.1	0.112	0.0107	0.1030	0.0980	0.0935	0.0873	0.0763	0.0660
0.15	0.102	0.0986	0.0948	0.0895	0.0851	0.0793	0.0680	0.0605
0.2	0.0926	0.0893	0.0856	0.0810	0.0770	0.0720	0.0615	0.0536
0.25	0.0843	0.0826	0.0793	0.0746	0.0710	0.0661	0.0567	0.0493
0.3	0.0810	0.0770	0.0746	0.0710	0.0671	0.0625	0.0535	0.0466
0.4	0.0700	0.0676	0.0665	0.0638	0.0600	0.0560	0.0470	0.0423
0.5	0.0460	0.0426	0.0423	0.0400	0.0370	0.0340	0.0290	0.0246
0.6	0.0323	0.0300	0.0293	0.0275	0.0261	0.0241	0.0210	0.0180
0.7	0.0243	0.0226	0.0200	0.0200	0.0190	0.0175	0.0150	0.0133
0.8	0.0183	0.0176	0.0158	0.0154	0.0149	0.0131	0.0118	0.0103

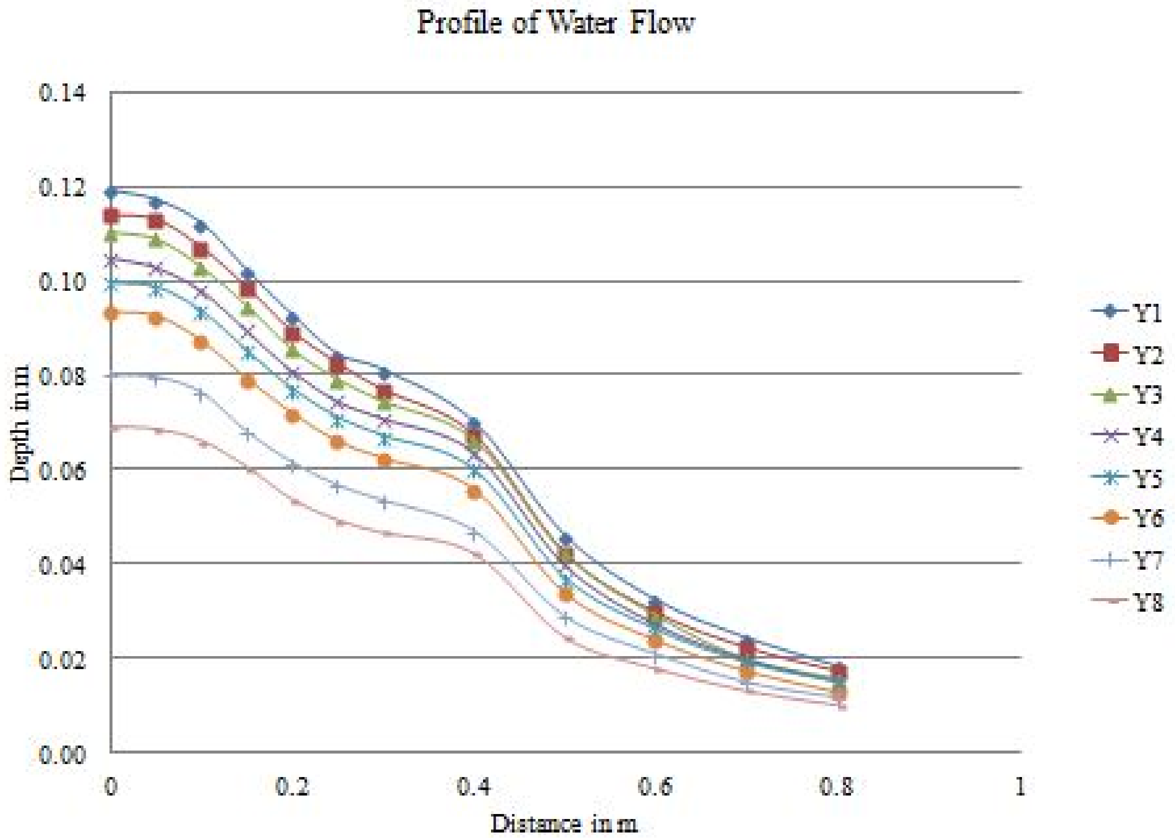


Figure 5.14: Profile of Water Flow in Trapezoidal Venturi Flume

5.3 Experiments On V-Shape Venturi Flumes

5.3.1 Experiment-1

- **In this Experiment Slope is Maintained by Flat. (S_0=Flat)**

Top View of V-Shape Venturi Flume

Front View of V-Shape Venturi Flume

Figure 5.15: Model Of V-Shape Venturi Flume

Table 5.19: Discharge and Depth Of Water Flow in V-Shape Venturi Flume

Manometer Readings (m)		Difference between two Limbs (m)	Pressure Head	Inlet Area (m^2)	Throat Area (m^2)	Discharge (m^3/sec)	Discharge (Lit/sec)	Depth Of Water Flow in V-Shaped Venturi Flume (m)	
h_1	h_2	X_m	H	A_1	A_2	Q	Q	Upstream	Throat
0.292	0.074	0.218	2.747	0.001948	0.000661	0.005515	5.515	0.143	0.114
0.283	0.083	0.200	2.520	0.001948	0.000661	0.005283	5.283	0.141	0.112
0.267	0.099	0.168	2.117	0.001948	0.000661	0.004842	4.842	0.136	0.108
0.251	0.112	0.139	1.751	0.001948	0.000661	0.004404	4.404	0.132	0.104
0.238	0.123	0.115	1.449	0.001948	0.000661	0.004006	4.006	0.127	0.100
0.224	0.138	0.086	1.084	0.001948	0.000661	0.003464	3.464	0.121	0.095
0.209	0.153	0.056	0.706	0.001948	0.000661	0.002795	2.795	0.112	0.088
0.195	0.166	0.029	0.365	0.001948	0.000661	0.002012	2.012	0.100	0.078

Table 5.20: Discharge and Depth

(Upstream - Throat) Depth in (m)	Average Depth (U+T/2 in (m)	Discharge in (m^3/sec)
X	**X**	**Y**
0.0293	0.1284	0.00552
0.0290	0.1260	0.00528
0.0280	0.1220	0.00484
0.0273	0.1178	0.00440
0.0262	0.1134	0.00401
0.0258	0.1076	0.00346
0.0239	0.0997	0.00280
0.0218	0.0886	0.00201

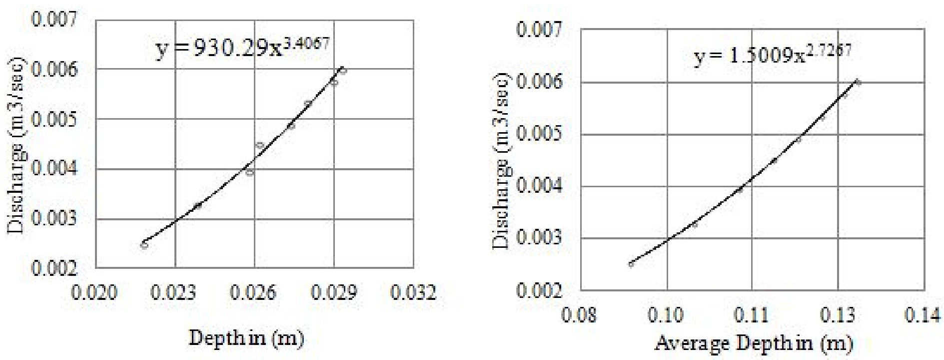


Figure 5.16: Graph Between The Depth and Discharge

Profile of Water Flow

Table 5.21: Depth Of Water Flow in V-Shape Venturi Flume Certain Intervals

Intervals in (m)	Y_1 Depth in (m)	Y_2 Depth in (m)	Y_3 Depth in (m)	Y_4 Depth in (m)	Y_5 Depth in (m)	Y_6 Depth in (m)	Y_7 Depth in (m)	Y_8 Depth in (m)
0	0.143	0.140	0.138	0.132	0.127	0.121	0.112	0.101
0.05	0.142	0.139	0.135	0.131	0.126	0.120	0.111	0.100
0.1	0.138	0.135	0.131	0.126	0.123	0.117	0.109	0.098
0.15	0.129	0.127	0.124	0.120	0.116	0.111	0.0103	0.092
0.2	0.123	0.120	0.117	0.113	0.109	0.103	0.095	0.085
0.25	0.117	0.114	0.112	0.107	0.103	0.098	0.090	0.080
0.3	0.112	0.110	0.106	0.103	0.099	0.093	0.087	0.077
0.4	0.101	0.100	0.097	0.094	0.091	0.086	0.079	0.071
0.5	0.070	0.066	0.066	0.061	0.060	0.052	0.046	0.038
0.6	0.036	0.037	0.035	0.031	0.028	0.026	0.022	0.017
0.7	0.024	0.024	0.023	0.021	0.020	0.017	0.015	0.012
0.8	0.018	0.018	0.017	0.016	0.015	0.013	0.011	0.008

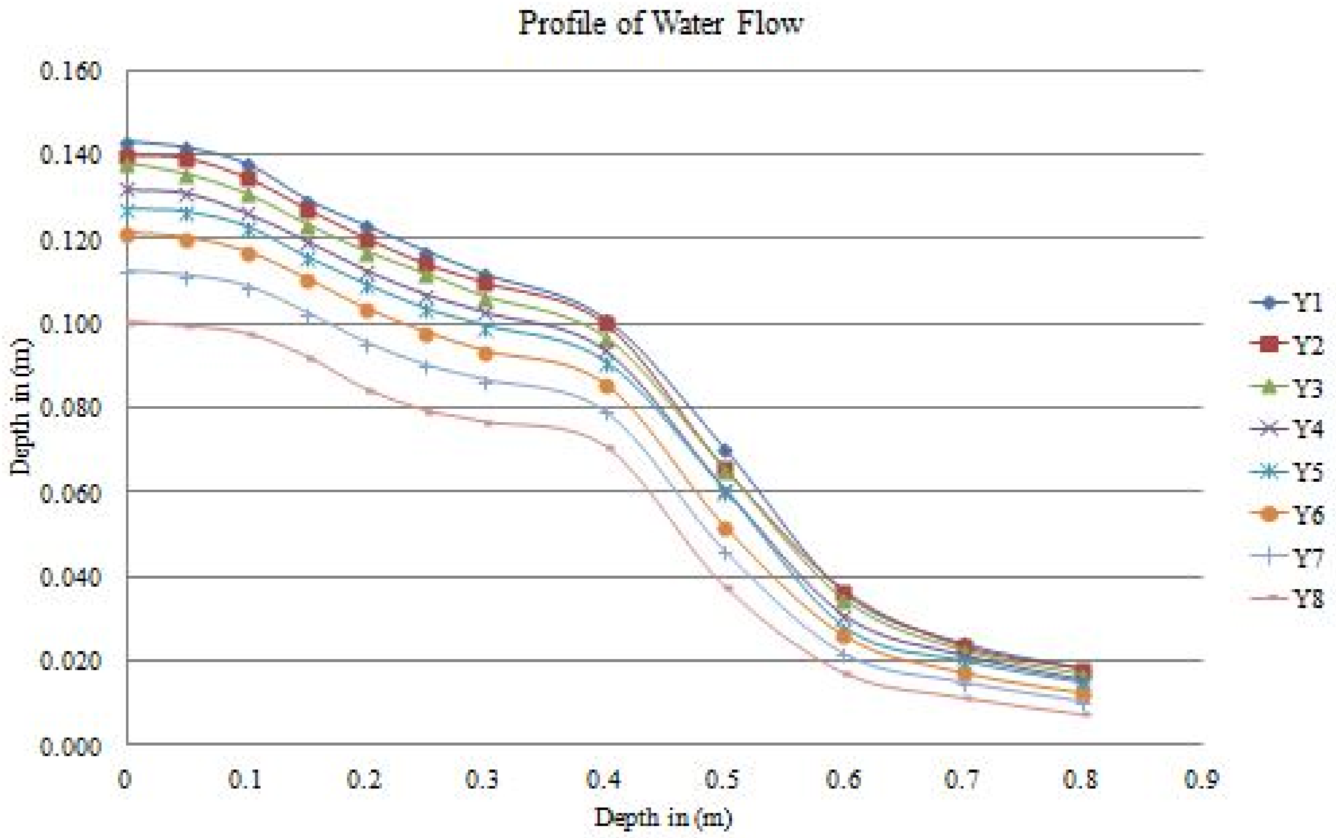


Figure 5.17: Profile of Water Flow in V-Shape Venturi Flume

5.3.2 Experiment-2

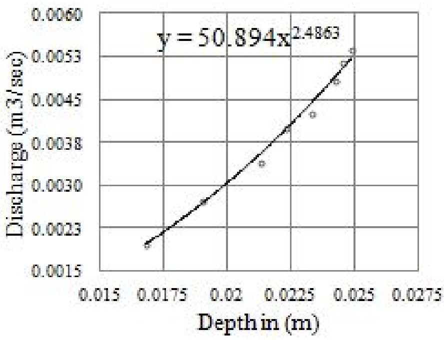
- **In this Experiment Slope is Maintained by 1 in 160. (S_0= 25mm)**

Table 5.22: Discharge and Depth Of Water Flow in V-Shape Venturi Flume

Manometer Readings (m)		Difference between two Limbs (m)	Pressure Head	Inlet Area (m^2)	Throat Area (m^2)	Discharge (m^3/sec)	Discharge (Lit/sec)	Depth Of Water Flow in V-Shaped Venturi Flume (m)	
h_1	h_2	X_m	H	A_1	A_2	Q	Q	Upstream	Throat
0.287	0.079	0.208	2.621	0.001948	0.000661	0.005387	5.387	0.135	0.110
0.278	0.087	0.191	2.407	0.001948	0.000661	0.005162	5.162	0.133	0.108
0.266	0.098	0.168	2.117	0.001948	0.000661	0.004842	4.842	0.130	0.106
0.247	0.117	0.130	1.638	0.001948	0.000661	0.004259	4.259	0.124	0.101
0.239	0.124	0.115	1.449	0.001948	0.000661	0.004006	4.006	0.121	0.099
0.223	0.140	0.083	1.046	0.001948	0.000661	0.003403	3.403	0.114	0.092
0.208	0.154	0.054	0.680	0.001948	0.000661	0.002745	2.745	0.104	0.085
0.194	0.166	0.028	0.353	0.001948	0.000661	0.001977	1.977	0.092	0.075

Table 5.23: Discharge and Depth

(Upstream - Throat) Depth in (m)	Average Depth (U+T/2 in (m)	Discharge in (m^3/sec)
X	**X**	**Y**
0.0249	0.1222	0.005387
0.0245	0.1203	0.005162
0.0242	0.1179	0.004842
0.0233	0.1124	0.004259
0.0223	0.1099	0.004006
0.0213	0.1029	0.003403
0.0190	0.0945	0.002745
0.0168	0.0836	0.001977



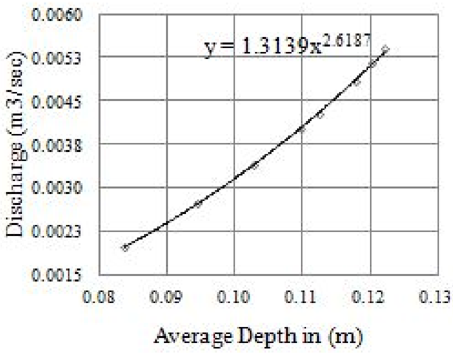


Figure 5.18: Graph Between The Depth and Discharge

Profile of Water Flow

Table 5.24: Depth Of Water Flow in V-Shape Venturi Flume Certain Intervals

Intervals in (m)	Y_1 Depth in (m)	Y_2 Depth in (m)	Y_3 Depth in (m)	Y_4 Depth in (m)	Y_5 Depth in (m)	Y_6 Depth in (m)	Y_7 Depth in (m)	Y_8 Depth in (m)
0	0.139	0.137	0.135	0.128	0.1253	0.1172	0.1083	0.0963
0.05	0.139	0.136	0.134	0.128	0.1245	0.1168	0.108	0.0960
0.1	0.134	0.132	0.129	0.124	0.122	0.1138	0.1065	0.0940
0.15	0.126	0.124	0.122	0.117	0.115	0.1080	0.1003	0.0900
0.2	0.119	0.117	0.115	0.110	0.108	0.101	0.0932	0.0818
0.25	0.113	0.111	0.109	0.104	0.102	0.0953	0.0873	0.0770
0.3	0.107	0.106	0.104	0.099	0.097	0.0907	0.0840	0.0735
0.4	0.098	0.096	0.094	0.090	0.089	0.0827	0.0767	0.0677
0.5	0.064	0.063	0.062	0.057	0.057	0.0505	0.0435	0.0352
0.6	0.035	0.033	0.032	0.029	0.027	0.023	0.0205	0.0157
0.7	0.022	0.022	0.020	0.019	0.018	0.0162	0.0135	0.0105
0.8	0.017	0.016	0.015	0.014	0.013	0.0110	0.0083	0.0065

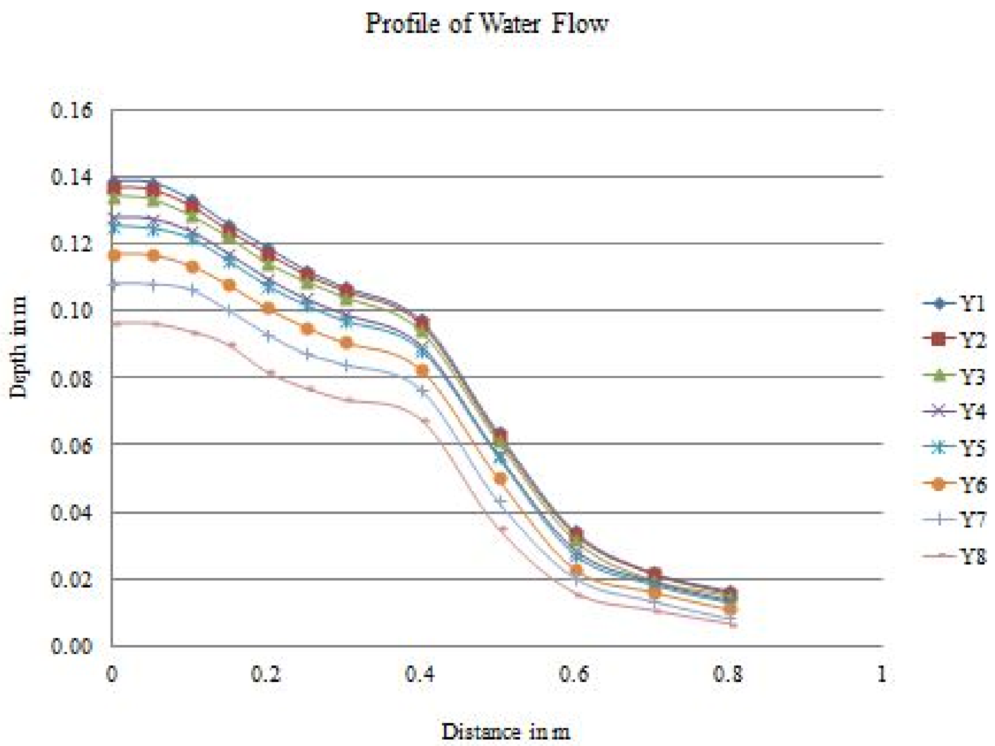


Figure 5.19: Profile of Water Flow in V-Shape Venturi Flume

5.3.3 Experiment-3

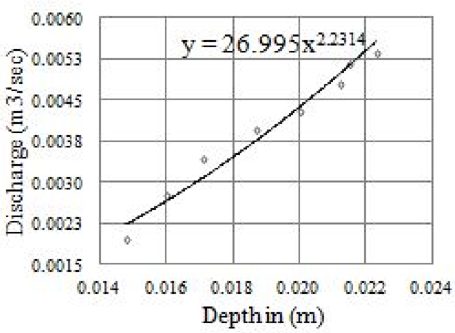
- **In this Experiment Slope is Maintained by 1 IN 80. (S_0= 50mm)**

Table 5.25: Discharge and Depth Of Water Flow in V-Shape Venturi Flume

Manometer Readings (m)		Difference between two Limbs (m)	Pressure Head	Inlet Area (m^2)	Throat Area (m^2)	Discharge (m^3/sec)	Discharge (Lit/sec)	Depth Of Water Flow in V-Shaped Venturi Flume (m)	
h_1	h_2	X_m	H	A_1	A_2	Q	Q	Upstream	Throat
0.286	0.080	0.206	2.596	0.001948	0.000661	0.005361	5.361	0.131	0.109
0.279	0.088	0.191	2.407	0.001948	0.000661	0.005162	5.162	0.129	0.108
0.265	0.101	0.164	2.066	0.001948	0.000661	0.004784	4.784	0.126	0.105
0.249	0.116	0.133	1.676	0.001948	0.000661	0.004308	4.308	0.120	0.100
0.238	0.126	0.112	1.411	0.001948	0.000661	0.003953	3.953	0.116	0.097
0.224	0.139	0.085	1.071	0.001948	0.000661	0.003444	3.444	0.110	0.093
0.209	0.154	0.055	0.693	0.001948	0.000661	0.002770	2.770	0.101	0.085
0.195	0.167	0.028	0.353	0.001948	0.000661	0.001977	1.977	0.090	0.075

Table 5.26: Discharge and Depth

(Upstream - Throat) Depth in (m)	**Average Depth (U+T/2 in (m)**	**Discharge in (m^3/sec)**
X	**X**	**Y**
0.0223	0.11985	0.00536
0.0215	0.11825	0.00516
0.0212	0.1154	0.00478
0.0200	0.1103	0.00431
0.0187	0.10665	0.00395
0.0171	0.10125	0.00344
0.0160	0.0927	0.00277
0.0148	0.0821	0.00198



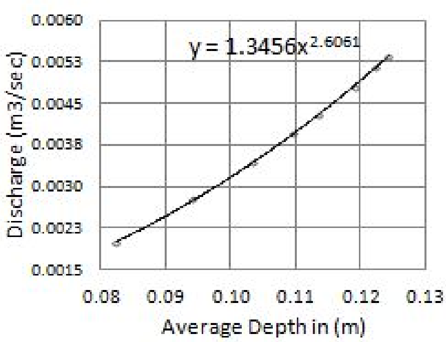


Figure 5.20: Graph Between The Depth and Discharge

Profile of Water Flow

Table 5.27: Depth Of Water Flow in V-Shape Venturi Flume Certain Intervals

Intervals in (m)	Y_1 Depth in (m)	Y_2 Depth in (m)	Y_3 Depth in (m)	Y_4 Depth in (m)	Y_5 Depth in (m)	Y_6 Depth in (m)	Y_7 Depth in (m)	Y_8 Depth in (m)
0	0.1383	0.1363	0.1332	0.1277	0.1235	0.1173	0.1089	0.0955
0.05	0.1378	0.1350	0.1327	0.1271	0.1228	0.1170	0.1085	0.0955
0.1	0.1337	0.1315	0.1287	0.1235	0.1197	0.1140	0.1057	0.0942
0.15	0.1257	0.1240	0.1215	0.1168	0.1127	0.1078	0.1003	0.0898
0.2	0.1187	0.1172	0.1145	0.1095	0.1055	0.1005	0.0923	0.0825
0.25	0.1123	0.1108	0.1083	0.1038	0.1007	0.0950	0.0875	0.0763
0.3	0.1070	0.1057	0.1030	0.0990	0.0950	0.0908	0.0833	0.0730
0.4	0.0973	0.0958	0.0933	0.0895	0.0870	0.0825	0.0738	0.0680
0.5	0.0653	0.0642	0.0607	0.0573	0.0540	0.0485	0.0410	0.0342
0.6	0.0348	0.0323	0.0310	0.0285	0.0263	0.0241	0.0204	0.0157
0.7	0.0223	0.0228	0.0218	0.0197	0.0178	0.0168	0.0143	0.0103
0.8	0.0167	0.0158	0.0153	0.0138	0.0123	0.0107	0.0087	0.0063

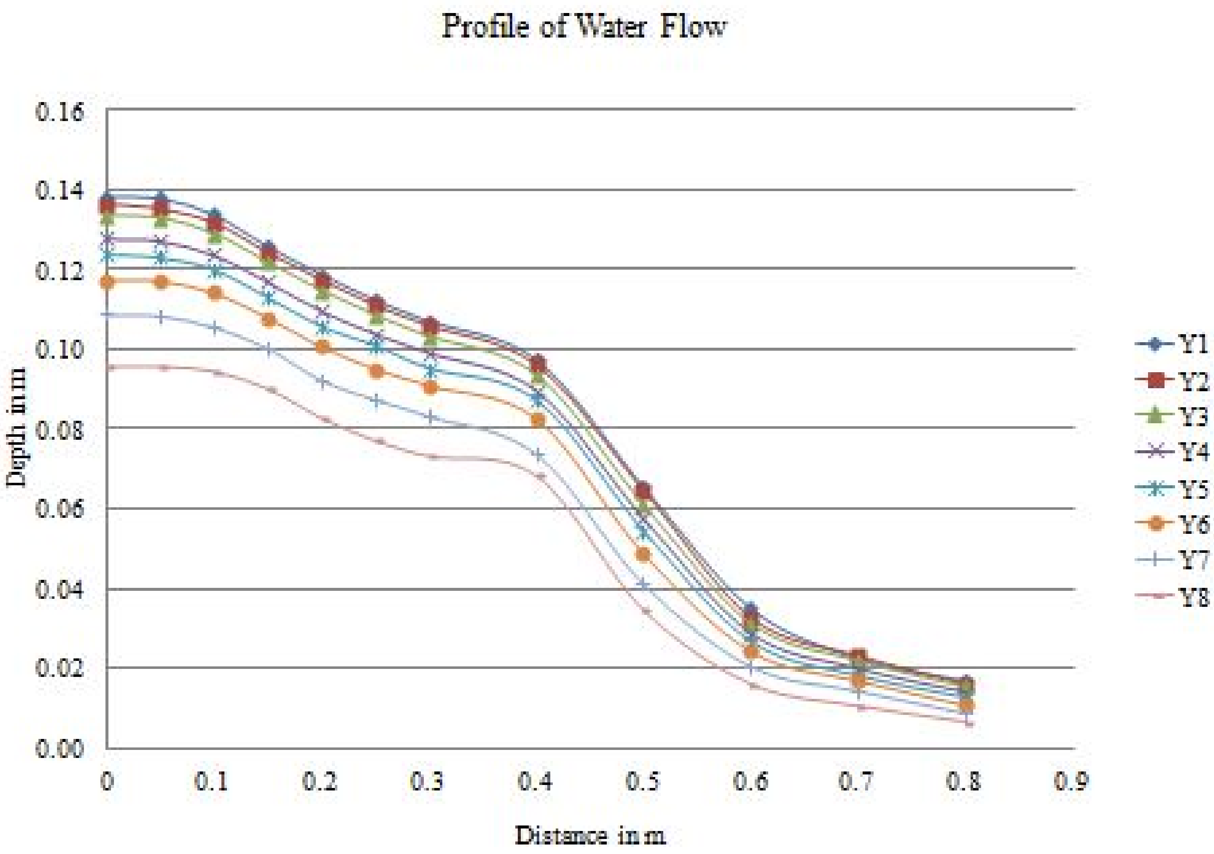


Figure 5.21: Profile of Water Flow in V-Shape Venturi Flume

Chapter 6

Aspect Ratio

6.1 Aspect Ratio

Aspect Ratio Defines as the ratio of Breadth to Depth. In Hydraulics Structures the higher aspect ratio result the side wall effect is less. If the Aspect Ratio is lessthan the 4, Sidewall effect is more.

Though decreasing channel aspect ratio or increasing channel height is favorable from thermal point of view, it is relatively difficult to manufacture low aspect ratio channel compared to high aspect ratio channels. Considering that higher aspect ratio channels are comparatively easy to manufacture and they are also thermally favorable if Greaterthan 2.0, for same thermal performance of two different aspect ratio channels, the micro-channel with higher aspect ratio should be preferred.

We discussed on the Sidewall effect on the basis of Aspect Ratio

1. Aspect Ratio is less than 4, the side wall effect is Increases.
2. Aspect Ratio is more than 4, the side wall effect is Decreases.

Sidewall Effect

The Sidewall effect is the problems in the open channel flow.

- Roughness of the sidewall
- Cross Sectional slope

- **Froude's Number F = V/sqrt(gD).**
- **Aspect Ratio = B/D**
- **Discharge Q = A.V (m^3/sec)**

Where

- **V = Velocity (m/sec).**
- **g = Acceleration due to gravity (m/sec^2).**
- **D = Depth (m).**

6.2 Sections

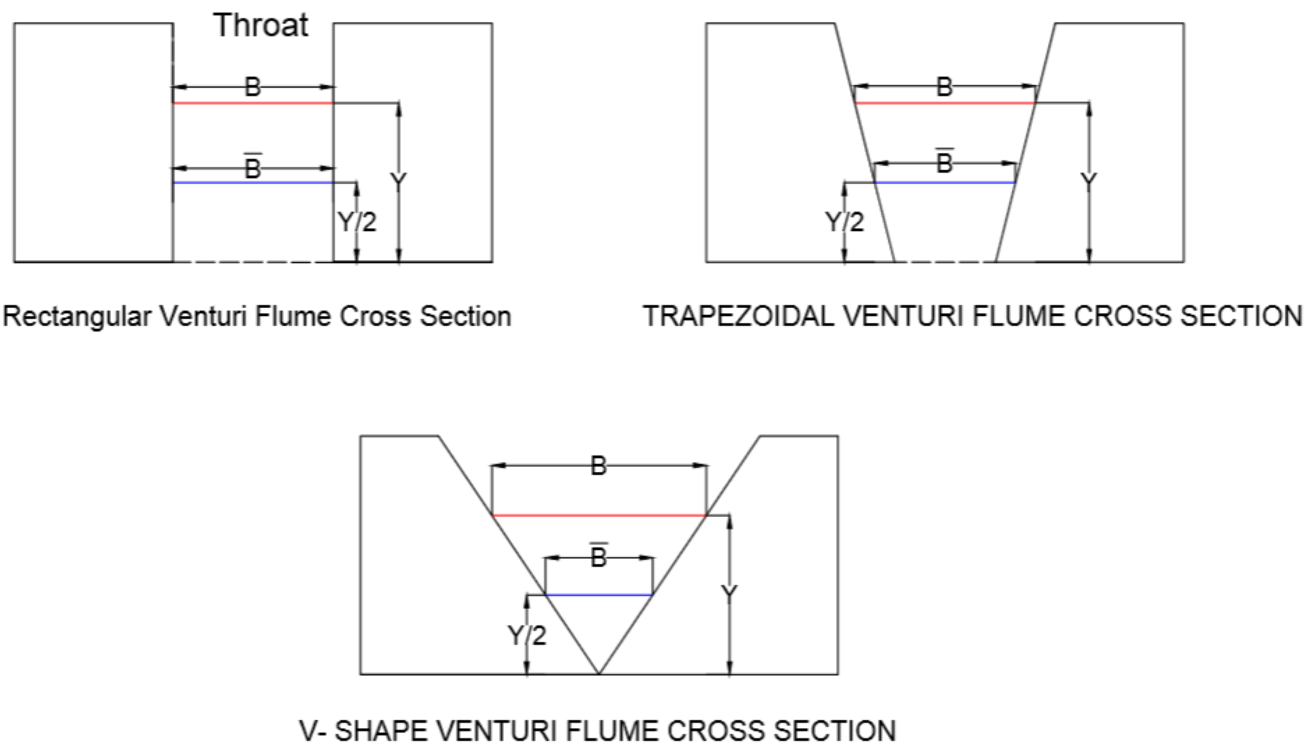


Figure 6.1: Different Sections

6.3 Aspect Ratio on Rectangle Venturi Flumes

6.3.1 Rectangle Venturi Flume (S_0 = Flat)

Table 6.1: Calculations of Froude's Number and Aspect Ratio

Discharge (m^3/sec)	**Wetted Area (m^2)**	**Velocity (m/sec)**	**Froude's Number**	**Aspect Ratio**
Q	**A**	**V**	**X**	**Y**
0.00566	0.0071	0.8013	0.9669	2.8857
0.00511	0.0066	0.7781	0.9744	3.1077
0.00472	0.0063	0.7545	0.9675	3.2581
0.00444	0.0061	0.7319	0.9540	3.3667
0.00404	0.0056	0.7234	0.9822	3.6528
0.00344	0.0051	0.6779	0.9650	4.0159
0.00277	0.0044	0.6291	0.9619	4.6330
0.00208	0.0037	0.5565	0.9237	5.4595

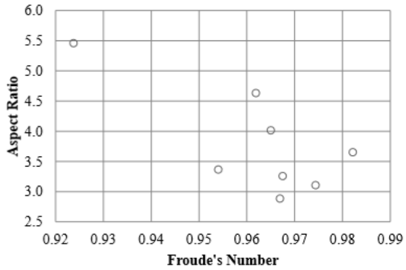


Figure 6.2: Graph for Froude's Number and Aspect Ratio

6.3.2 Rectangle Venturi Flume (S_1 = 1 in 180)

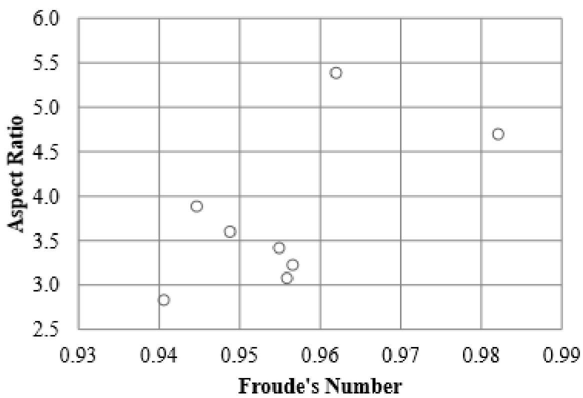


Figure 6.3: Graph for Froude's Number and Aspect Ratio

Table 6.2: Calculations of Froude's Number and Aspect Ratio

Discharge (m^3/**sec**)	**Wetted Area** (m^2)	**Velocity (m/sec)**	**Froude's Number**	**Aspect Ratio**
Q	**A**	**V**	**X**	**Y**
0.00566	0.0072	0.7867	0.9406	2.8331
0.00508	0.0066	0.7668	0.9559	3.0793
0.00474	0.0063	0.7496	0.9566	3.2268
0.00434	0.0060	0.7271	0.9549	3.4179
0.00399	0.0057	0.7039	0.9488	3.6007
0.00354	0.0053	0.6747	0.9447	3.8846
0.00277	0.0043	0.6379	0.9821	4.6977
0.00221	0.0038	0.5835	0.9620	5.3867

6.3.3 Rectangle Venturi Flume (S_2 = 1 in 80)

Table 6.3: Calculations of Froude's Number and Aspect Ratio

Discharge (m^3/**sec**)	**Wetted Area** (m^2)	**Velocity (m/sec)**	**Froude's Number**	**Aspect Ratio**
Q	**A**	**V**	**X**	**Y**
0.00566	0.0072	0.7834	0.9347	2.8212
0.00504	0.0066	0.7657	0.9577	3.1001
0.00440	0.0060	0.7378	0.9689	3.4179
0.00392	0.0053	0.7374	1.0266	3.8403
0.00315	0.0049	0.6452	0.9373	4.1822
0.00221	0.0041	0.5402	0.8571	4.9877
0.00215	0.0036	0.6019	1.0228	5.7224
0.00211	0.0030	0.6974	1.2855	6.7333

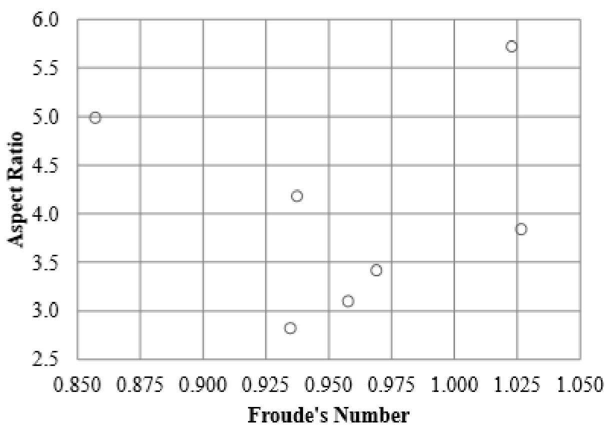


Figure 6.4: Graph for Froude's Number and Aspect Ratio

6.4 Aspect Ratio on Trapezoidal Venturi Flumes

6.4.1 Trapezoidal Venturi Flume (S_0 = Flat)

Table 6.4: Calculations of Froude's Number and Aspect Ratio

Discharge (m^3/sec)	**Wetted Area (m^2)**	**Velocity (m/sec)**	**Breadth (m)**	**Froude's Number**	**Aspect Ratio**
Q	**A**	**V**	**B**	**X**	**Y**
0.00554	0.0072	0.7668	0.1061	0.8388	2.4906
0.00528	0.0070	0.7520	0.1052	0.8319	2.5246
0.00483	0.0066	0.7271	0.1033	0.8228	2.5955
0.00445	0.0063	0.7099	0.1015	0.8222	2.6711
0.00394	0.0058	0.6764	0.0993	0.8076	2.7762
0.00334	0.0052	0.6445	0.0960	0.8071	2.9538
0.00256	0.0043	0.5951	0.0913	0.8057	3.2842
0.00198	0.0033	0.5952	0.0858	0.9008	3.8539

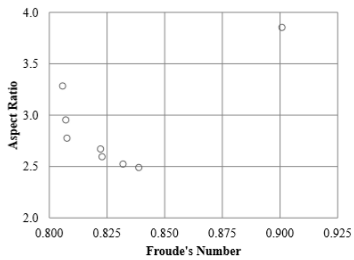


Figure 6.5: Graph for Froude's Number and Aspect Ratio

6.4.2 Trapezoidal Venturi Flume (S_1 = 1 in 180)

Table 6.5: Calculations of Froude's Number and Aspect Ratio

Discharge (m^3/sec)	**Wetted Area (m^2)**	**Velocity (m/sec)**	**Breadth (m)**	**Froude's Number**	**Aspect Ratio**
Q	**A**	**V**	**B**	**X**	**Y**
0.00543	0.0068	0.7962	0.1042	0.8915	2.5621
0.00534	0.0068	0.7865	0.1040	0.8823	2.5679
0.00480	0.0063	0.7616	0.1017	0.8802	2.6645
0.00444	0.0060	0.7371	0.1003	0.8680	2.7279
0.00395	0.0055	0.7209	0.0976	0.8820	2.8649
0.00346	0.0051	0.6834	0.0954	0.8638	2.9906
0.00280	0.0043	0.6441	0.0915	0.8690	3.2679
0.00194	0.0033	0.5830	0.0858	0.8813	3.8475

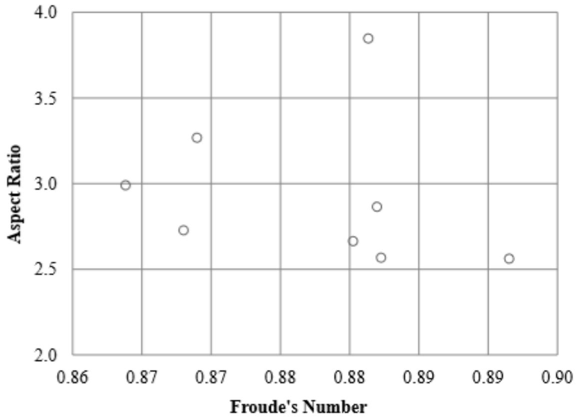


Figure 6.6: Graph for Froude's Number and Aspect Ratio

6.4.3 Trapezoidal Venturi Flume (S_2 = 1 in 80)

Table 6.6: Calculations of Froude's Number and Aspect Ratio

Discharge (m^3/sec)	**Wetted Area (m^2)**	**Velocity (m/sec)**	**Breadth (m)**	**Froude's Number**	**Aspect Ratio**
Q	**A**	**V**	**B**	**X**	**Y**
0.00555	0.0070	0.7941	0.1050	0.8800	2.5301
0.00520	0.0067	0.7789	0.1035	0.8792	2.5875
0.00491	0.0063	0.7760	0.1018	0.8952	2.6580
0.00444	0.0059	0.7559	0.0995	0.8994	2.7639
0.00409	0.0055	0.7502	0.0974	0.9198	2.8732
0.00360	0.0050	0.7147	0.0953	0.9055	3.0000
0.00280	0.0042	0.6650	0.0908	0.9095	3.3303
0.00224	0.0036	0.6290	0.0872	0.9235	3.6850

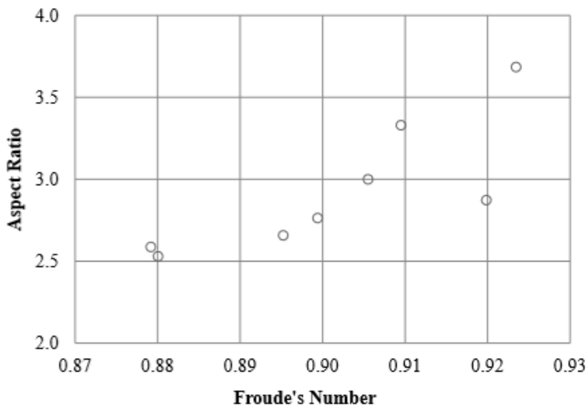


Figure 6.7: Graph for Froude's Number and Aspect Ratio

6.5 Aspect Ratio on V-Shape Venturi Flumes

6.5.1 V-Shape Venturi Flume (S_0 = Flat)

Table 6.7: Calculations of Froude's Number and Aspect Ratio

Discharge (m^3/sec)	**Wetted Area (m^2)**	**Velocity (m/sec)**	**Breadth (m)**	**Froude's Number**	**Aspect Ratio**
Q	**A**	**V**	**B**	**X**	**Y**
0.00552	0.0087	0.6324	0.0767	0.5988	1.3492
0.00528	0.0084	0.6288	0.0754	0.6012	1.3516
0.00484	0.0079	0.6166	0.0727	0.5991	1.3463
0.00440	0.0073	0.6027	0.0702	0.5962	1.3468
0.00401	0.0068	0.5917	0.0675	0.5965	1.3460
0.00346	0.0060	0.5738	0.0638	0.5953	1.3464
0.00280	0.0052	0.5387	0.0591	0.5804	1.3462
0.00201	0.0040	0.4979	0.0520	0.5702	1.3385

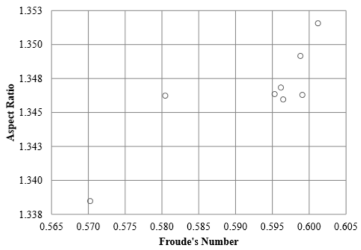


Figure 6.8: Graph for Froude's Number and Aspect Ratio

6.5.2 V-Shape Venturi Flume (S_1 = 1 in 180)

Table 6.8: Calculations of Froude's Number and Aspect Ratio

Discharge (m^3/sec)	**Wetted Area (m^2)**	**Velocity (m/sec)**	**Breadth (m)**	**Froude's Number**	**Aspect Ratio**
Q	**A**	**V**	**B**	**X**	**Y**
0.00539	0.0081	0.6639	0.0739	0.6397	1.3461
0.00516	0.0079	0.6575	0.0727	0.6388	1.3463
0.00484	0.0075	0.6427	0.0712	0.6309	1.3459
0.00426	0.0068	0.6238	0.0678	0.6276	1.3466
0.00401	0.0066	0.6108	0.0665	0.6207	1.3465
0.00340	0.0057	0.5948	0.0621	0.6255	1.3460
0.00274	0.0049	0.5646	0.0572	0.6183	1.3459
0.00198	0.0038	0.5194	0.0506	0.6048	1.3457

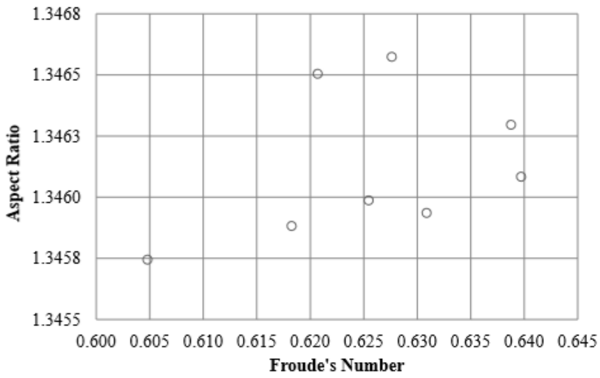


Figure 6.9: Graph for Froude's Number and Aspect Ratio

6.5.3 V-Shape Venturi Flume (S_2 = 1 in 80)

Table 6.9: Calculations of Froude's Number and Aspect Ratio

Discharge (m^3/sec)	**Wetted Area (m^2)**	**Velocity (m/sec)**	**Breadth (m)**	**Froude's Number**	**Aspect Ratio**
Q	**A**	**V**	**B**	**X**	**Y**
0.00536	0.0080	0.6738	0.0732	0.6525	1.3468
0.00516	0.0078	0.6637	0.0724	0.6463	1.3460
0.00478	0.0074	0.6470	0.0706	0.6381	1.3464
0.00431	0.0068	0.6363	0.0675	0.6415	1.3460
0.00395	0.0064	0.6203	0.0655	0.6349	1.3464
0.00344	0.0058	0.5954	0.0624	0.6243	1.3463
0.00277	0.0048	0.5738	0.0570	0.6295	1.3459
0.00198	0.0038	0.5260	0.0503	0.6145	1.3467

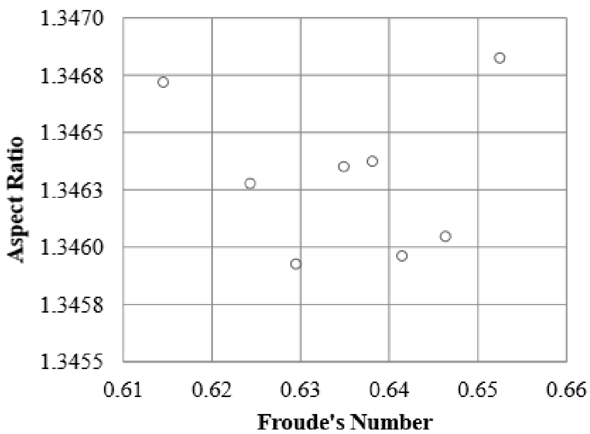


Figure 6.10: Graph for Froude's Number and Aspect Ratio

Chapter 7

Results And Discussion

7.1 Discharge Equation Results

The Discharge Equations Obtained from the Graphs (Average Depth of Upstream and Throat vs Discharge)

Rectangle Venturi Flume

- **Flat Slope Q** $= 0.2293y^{1.5374}$
- **1 in 160 Slope Q** $= 0.1897y^{1.4566}$
- **1 in 80 Slope Q** $= 0.1079y^{1.2275}$

Trapezoidal Venturi Flume

- **Flat Slope Q** $=0.2071y^{1.6079}$
- **1 in 160 Slope Q** $= 0.2731y^{1.6805}$
- **1 in 80 Slope Q** $=0.2355y^{1.609}$

V-Shaped Venturi Flume

- **Flat Slope Q** $= 1.5009y^{2.7267}$
- **1 in 160 Slope Q** $= 1.3139y^{2.6187}$

- **1 in 80 Slope Q** $= 1.3456y^{2.6061}$

7.2 Aspect Ratio Results

The Average Aspect Ratio Values Obtained by Calculating the Average Breadth/Average Depth.

Rectangle Venturi Flume

- **Average Aspect Ratio For Flat Slope is 3.7974**
- **Average Aspect Ratio For 1 in 160 Slope is 3.8259**
- **Average Aspect Ratio For 1 in 80 Slope is 4.3506**

Trapezoidal Venturi Flume

- **Average Aspect Ratio For Flat Slope is 2.8937**
- **Average Aspect Ratio For 1 in 160 Slope is 2.9367**
- **Average Aspect Ratio For 1 in 80 Slope is 2.9285**

V-Shaped Venturi Flume

- **Average Aspect Ratio For Flat Slope is 1.3464**
- **Average Aspect Ratio For 1 in 160 Slope is 1.3461**
- **Average Aspect Ratio For 1 in 80 Slope is 1.3463**

Chapter 8

Conclusions

- **After investigating the Venturi Flumes with Rectangular , Trapezoidal and V-shaped ,for flat slope there is no change in water depth of upstream (which is measured 50cm from the inlet) to Inlet.**
- **For 1 in 160 Slope, the water level has raised by 4-5mm From upstream (which is measured 50cm from the inlet) to Inlet.**
- **For 1 in 80 Slope, the water level has raised by 7 mm from upstream (which is measured 50cm from the inlet) to Inlet.**
- **Study on profile of the water flow , we say that the water level is increased at upstream side and decreased at downstream side.**
- **Study on Aspect Ratio vs Frodue's Number, higher the aspect ratio the effect of the side wall is less. From this study on Venturi flumes we get higher aspect ratio for Rectangular Venturi flume, So the side wall effect is less.**

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