ISSN XXXX XXXX © 2018 IJESC

IJESC

Research Article Volume 8 Issue No.5

Hydraulic Investigation of Floating Miniature Venturiflume

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Abstract:
One of the important problem in irrigation is measuring irrigation water that flows in open channel. Several devices has been used for measuring irrigation water including weirs and Parshall flumes. Unfortunately, at many locations where flow measurement is desired there may be insufficient space available for operation of a critical-flow measurement structure under all flow conditions that may occur. Using the Conventional technique for measuring discharge in open channel flow a new technique of discharge measurement is being developed by calibration of miniature venturiflume in floating condition to facilitate discharge measurement, which will lead the work in efficient way and achieving economy and accuracy.

Keywords: Discharge measurement, Conventional venturiflume Miniature Venturiflume, Open channel.

I. INTRODUCTION

One of the important problems in irrigation is measuring irrigation water that flows in open channel. Several devices have been used for measuring irrigation water including weirs and Parshall flumes. In areas of flat topography, low canal gradients and lack of freeboard may not provide sufficient head to allow use of such devices. One of the main disadvantages of weirs and Parshall flumes in canals of flat gradients is the reduction of the capacity of the canal owing to the further reduction of the gradient. A Venturiflume is a critical-flow flume, where in the critical depth is created by a local reduction of the channel width. For open channel conveyance systems, the Venturiflume offers the simplicity of a direct correlation between the upstream head and a corresponding discharge. Compared to a weir, this flume possesses the advantages of operating successfully without significant deposition of sediments and conveying water with smaller energy losses. If the Venturiflume is designed to be operated under free flow conditions, the flow passes from the subcritical to the supercritical state through the flume channel.
Following are the desirable characteristics of a suitable water measuring devices for use in canals of low gradients.

1. A low resistance to flow i.e. low head loss.
2. Easily measurable head.
3. Small effect on silt and debris deposition.
4. Simple construction and low cost.
5. Freedom from clogging by floating debris.

The evolving circumstances under which irrigation operate include growing demands for more accurate knowledge and accountability of flow throughout the conveyance network, along with increased needs for timely awareness when unexpected flow conditions are present. For Open channel conveyance systems, critical-flow structures offer the simplicity of a direct correlation between upstream water level and a corresponding discharge. Unfortunately, at many locations where flow measurement is desired there may be insufficient space available for operation of a critical-flow measurement structure under all flow conditions that may occur.

II. CONVENTIONAL VENTURIFLUME IN FLOATING CONDITION

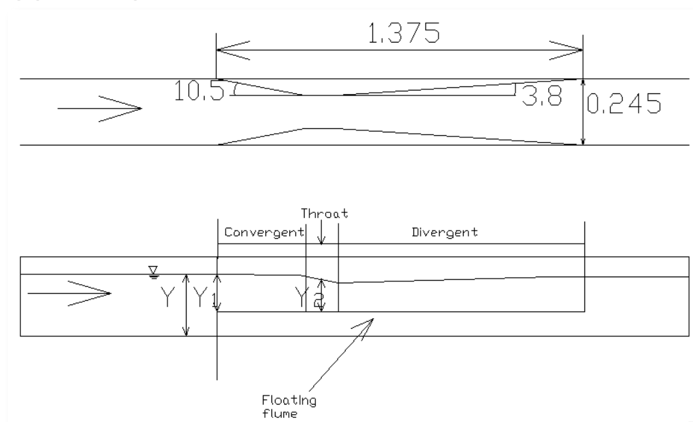


Figure.1. Conventional Venturiflume In Floating Condition

For experiment purpose the venturiflume is designed for full width of channel in floating condition then flume is considered as a Conventional flume in floating condition.

Equation of venturiflume,

$$Q = C_d \frac{a_1 a_2 \sqrt{2gh}}{\sqrt{a_1^2 - a_2^2}} \quad \text{..........................(1)}$$

Where,

$a_1 = b_1 y_1 \qquad a_2 = b_2 y_2$.................. (2)

Q = Discharge in m^3/sec.
Cd = Coefficient of discharge.
a_1 = Area of inlet in m^2.
a_2 = Area of throat in m^2.
b_1 = Width of inlet in m.
b_2 = Width of throat in m.
$h = y_1 - y_2$

III. MINIATURE VENTURIFULMES IN FLOATING CONDITION

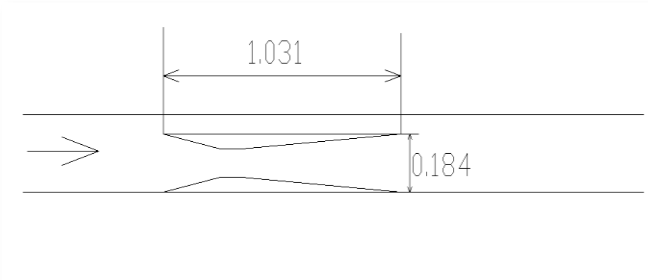


Figure.2. 75% miniature venturiflume

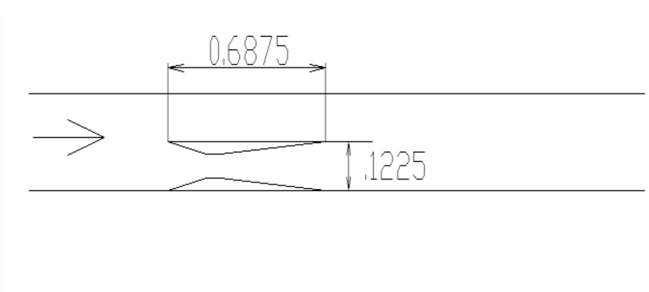


Figure.3. 50% miniature venturiflume

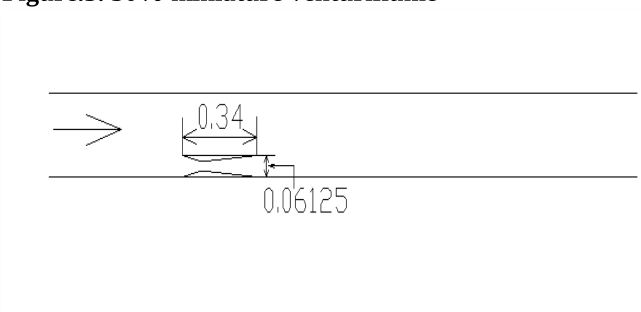


Figure.4. 25% miniature venturiflume

For design of miniature venturiflume the three different reductions are considered. The height of miniature venturiflume kept same as height of conventional venturiflume. The percentage considered for width reductions are 25%, 50%, 75%. The reduction percentage of miniature venturiflumes are respect to conventional venturiflume.

Equation of Miniature Venturiflume,

$$Q' = C_d' \frac{a_1' a_2' \sqrt{2gh'}}{\sqrt{a_1'^2 - a_2'^2}} \text{..................(3)}$$

Where,

$a_1' = b_1' y_1' \quad a_2' = b_2' y_2'$..................(4)

Q' = Discharge in m^3/sec.

C_d' = Coefficient of discharge.

a_1' = Area of inlet in m^2.

a_2' = Area of throat in m^2.

b_1' = Width of inlet in m.

b_2' = Width of throat in m.

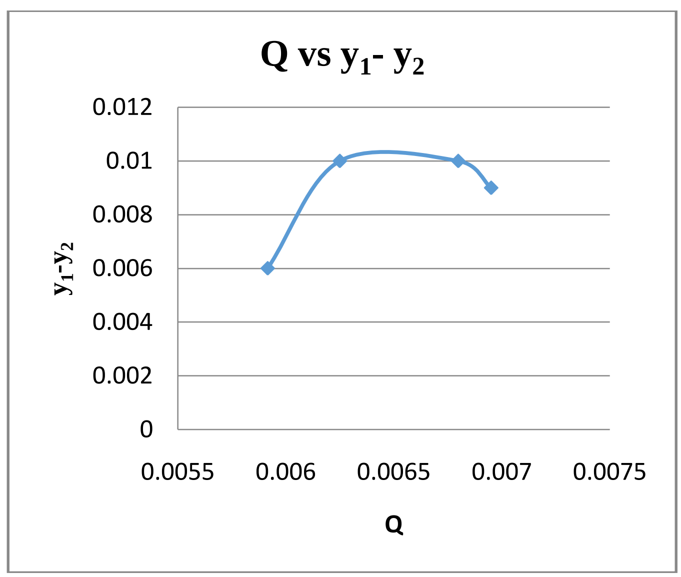
h'= $y_{1'} - y_{2'}$

IV. EXPERIMENTATION ON CONVENTIONAL VENTURIFLUME IN FLOATING CONDITION

Figure.5. Conventional Venturifulme In Floating Condition

Table.1. Conventional Venturiflume in floating Condition

t (sec)	Q (cumec)	y (m)	y_1 (m)	y_2 (m)	a_1 (m^2)	a_2 (m^2)	h (m)	Cd
2.23	0.0069	0.093	0.041	0.032	0.0099	0.0038	0.009	3.93
2.28	0.0067	0.095	0.045	0.035	0.0109	0.0042	0.01	3.34
2.48	0.0062	0.089	0.044	0.034	0.0106	0.0041	0.01	3.16
2.62	0.0059	0.074	0.037	0.031	0.0089	0.0037	0.006	4.17



Graph.1. Discharge vs Head

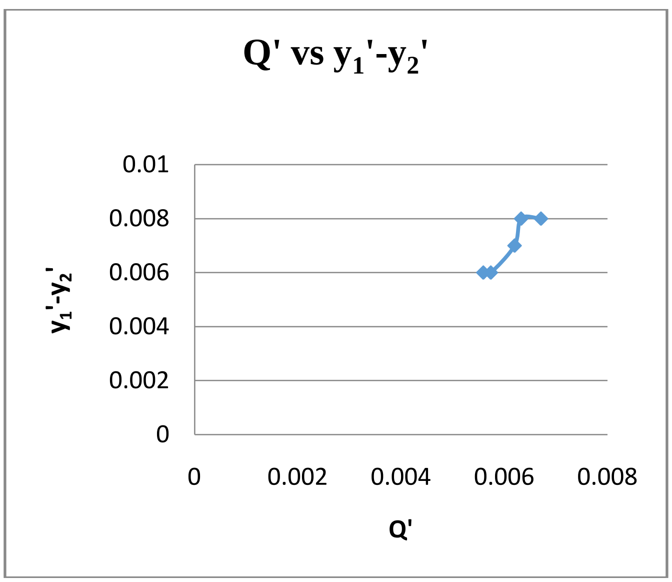
Graph 1 shows the curve obtained for Q vs y_1 - y_2. It clearly shows that difference between depth at inlet and at throat in floating condition is increases as discharge increases. From Table 1 it is clear that the value of Cd is around 3.5. For Conventional flume it is 0.92-0.98. For verification of Cd numbers of sets of experimentation have been done. Since value of Cd is changed due to floating condition.

V. Experimentation On Miniature Venturiflume In Floating Condition (75%)

Figure.6. Miniature Venturiflume In Floating Condition (75%)

Table.2. Miniature Venturiflume in floating Condition (75%)

t (sec)	Q' (Cumec)	y' (m)	y_1' (m)	y_2' (m)	h' (m)	a_1' (m^2)	a_2' (m^2)	Cd'
2.31	0.00671	0.097	0.049	0.041	0.008	0.00882	0.003948	3.84
2.45	0.006327	0.095	0.046	0.038	0.008	0.00828	0.003572	4.03
2.5	0.0062	0.093	0.042	0.035	0.007	0.00756	0.00329	4.58
2.7	0.005741	0.081	0.039	0.033	0.006	0.00702	0.003196	4.66
2.77	0.005596	0.066	0.032	0.026	0.006	0.00576	0.002726	5.27
3.25	0.004769	0.064	0.032	0.026	0.006	0.00576	0.002726	4.49



Graph.2. Discharge vs Head

Graph 2 shows the curve obtained for Q' vs y_1' - y_2'. It clearly shows that difference between depth at inlet and at throat in floating condition is increases as discharge increases. From Table 2 it is clear that the value of Cd is in the range of 3-4. For Conventional flume it is 0.92-0.98. For verification of Cd numbers of sets of experimentation have been done. Since value of Cd is changed due to floating condition and width reduction.

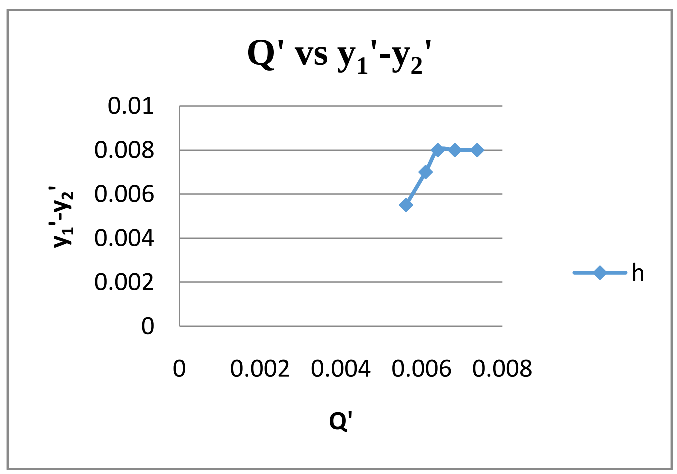
VI. Experimentation on Miniature Venturiflume in Floating Condition (50%)

Figure.7.Miniature Venturifulme In Floating Condition (50%)

Fig 7 shows miniature venturiflume in floating condition (50%). The flume is installed on one side of tilting flume with floating arrangement.

Table.3. Miniature Venturiflume in floating Condition(50%)

t (sec)	Q' (Cumec)	y' (m)	y_1' (m)	y_2' (m)	h' (m)	a_1' (m^2)	a_2' (m^2)	Cd'
2.1	0.0074	0.097	0.05	0.042	0.0059	0.00252	0.008	6.68
2.27	0.0068	0.089	0.046	0.037	0.0054	0.00225	0.008	6.76
2.42	0.0064	0.093	0.045	0.037	0.0053	0.00222	0.008	6.61
2.54	0.0061	0.093	0.046	0.039	0.0054	0.00234	0.007	6.34
2.76	0.0056	0.089	0.046	0.0405	0.0054	0.00243	0.007	6.29



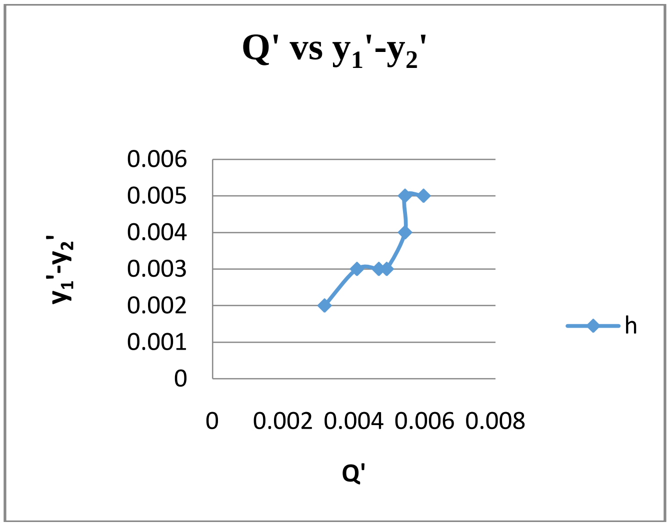
Graph.3. Discharge VS Head

Graph 3 shows the curve obtained for **Q' vs y_1' - y_2'**. It clearly shows that difference between depth at inlet and at throat in floating condition is increases as discharge increases. The same shows the Graph 1 & 2. From Table 3 it is clear that the value of Cd is around 6.5. For Conventional flume it is 0.92-0.98. For verification of Cd numbers of sets of experimentation have been done. Since value of Cd is changed due to floating condition and width reduction.

VII. EXPERIMENTATION ON MINIATURE VENTURIFLUME IN FLOATING CONDITION (25%)

Table .4. Miniature Venturiflume in floating Condition(25%)

t (sec)	Q' (Cumec)	y' (m)	y_1' (m)	y_2' (m)	h' (m)	a_1' (m^2)	a_2' (m^2)	Cd'
2.6	0.005962	0.01	0.05	0.045	0.003	0.00135	0.005	12.59
2.7	0.005741	0.077	0.045	0.04	0.0027	0.00126	0.005	16.61
2.8	0.005536	0.093	0.046	0.042	0.00276	0.00126	0.004	13.95
2.85	0.005439	0.094	0.047	0.042	0.00282	0.00126	0.005	12.33
2.85	0.005439	0.01	0.05	0.046	0.003	0.00138	0.004	12.49
3.15	0.004921	0.096	0.047	0.044	0.00282	0.00132	0.003	13.58
3.3	0.004697	0.09	0.044	0.041	0.00264	0.00123	0.003	13.93
3.8	0.004079	0.089	0.044	0.041	0.00264	0.00123	0.003	12.09



Graph.4. Discharge VS Head

Graph 4 shows the curve obtained for **Q' vs y_1' - y_2'**. It clearly shows that difference between depth at inlet and at throat in floating condition is increases as discharge increases. The same shows the Graph 1, 2 & 3.

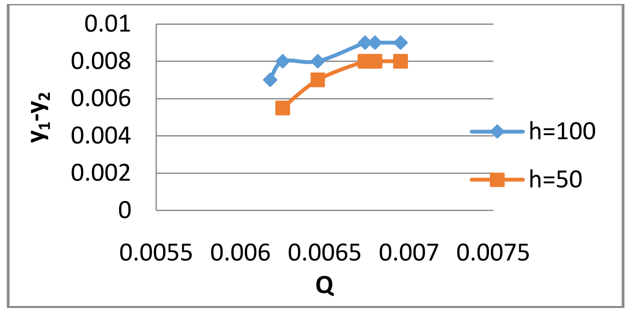
From **Table 4** it is clear that the value of Cd is around 12.8. For Conventional flume it is 0.92-0.98. For verification of Cd numbers of sets of experimentation have been done. Since value of Cd is changed due to floating condition and width reduction.

VIII. GRAPHICAL ANALYSIS OF CONVENTIONAL VENTURIFLUME & MINIATURE VENTURIFLUME

After graphical analysis of miniature venturiflumes i.e. 75%, 50% & 25% with conventional miniature venturiflume, 50% miniature venturiflume shows same trend of curve.

Table.5. Comparison between Conventional Venturiflume & Miniature Venturiflume (50%)

Q (Cumec)	y_1-y_2=100% (m)	y_1'-y_2'=50% (m)
0.006951	0.009	0.008
0.006798	0.009	0.008
0.006739	0.009	0.008
0.006458	0.008	0.007
0.00625	0.008	0.0055

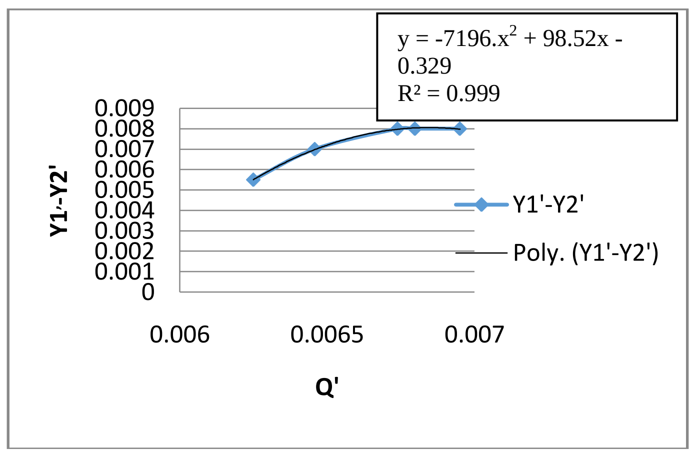


Graph.5. Comparison between Conventional and Miniature venturiflume (50%)

Graph 5 shows the curve obtained **Q vs y_1–y_2** for Conventional and miniature venturiflume. The two different curves shows same trend of line.

IX. RESULT & DISCUSSION

The table shows depths at inlet and throat section for miniature venturiflume. After experimentation the actual discharge is found out. The value of Cd' is obtained and the average Cd' is calculated. Since the value of Cd' is 6.5. With this obtained value theoretical discharge is calculated and % error is obtained. The % error is between ± 5% and it is acceptable.



Graph.4. Discharge vs Head for miniature venturiflume

Graph 4 shows a equation $y = -7196.x^2 + 98.52x - 0.329$ which is obtained from graph.

$$y = -7196.x^2 + 98.52x - 0.329 \quad \ldots\ldots\ldots\ldots(5)$$

Where,

$y = y_1' - y_2'$

$x = Q$

Hence, range of Cd (coefficient of discharge) for Conventional flume is 0.92 to 0.98 but in case of miniature venturiflume in floating condition it is 6.5.Since discharge of full channel is measured with the help of miniature venturiflume i.e. ½ width of channel with taking 6.5 as a value of Cd.

BENEFITS OF MINIATURE VENTURIFLUME:

1. The construction cost of miniature flume will be less than the conventional venturiflume.
2. The problem of sedimentation will be solved as the flume is in floating condition.
3. In miniature venturiflume measurement of depths at inlet and throat is an easy task as compared to conventional flume.

FUTURE SCOPE:

4. In this project ratio of dimensions of conventional and miniature venturiflume kept 75%, 50% and 25%. In future different ratios can be taken for study.
5. By providing different positions of miniature venturiflume in floating condition in channel, further study can be done.
6. Automation for depth and discharge measurement with the help of advanced electronic instruments can be done to minimize the error.
7. Wide range of discharge can be studied using different venturiflumes.

LIMITATION:

This study is completed in rectangular tilting flume, so result may change for trapezoidal flume.

X. CONCLUSION

For Conventional venturiflume and miniature venturiflume a relation is obtained , which will lead the work in efficient and economic way.

1. The proposed model is feasible for design discharge of 0.007 m3/sec .
2. Coefficient of discharge= 6.5.
3. Economy is achieved due to reduced dimensions of new venturiflume.
4. The equations obtained is

y=-7196.x2+98.52x-0.329

$R^2 = 0.999$

XI. ACKNOWLEDGEMENT

I express my sincere thanks to my guide Prof. S. S. Hailkar and Head of Department of Civil Engineering Dr. S. S. Shastri. Without their inspiration and help it would not have been possible for me to complete this project.

I would like to express my sincere thanks to Dr. S. D. Lokhande, Principal of Sinhgad College of Engineering for his helpful suggestions.

I thanks to all those who have contributed directly or indirectly to this work.

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