Calibration of Compound Broad Crested Weir For Measurement of Discharge

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Abstract- *Experiments were carried out to know the suitability of different shapes of broad crested weirs to replace the conventional method of discharge measurement with the help of venturi-flume. Even the weir used for it, had an indepen0dent use as energy dissipater. A series of laboratory experiments were performed in order to investigate the effects of the lower weir crest and step height of a broad-crested weir of rectangular compound cross section on the values of discharge coefficient, the approach velocity and the modular limit. The dependence of the three values on model parameters was investigated and the quantities were compared with those of the broad crested weir models with rectangular cross section.*

Keywords- Co-efficient of Discharge, Calibration of Weir,Broad crested weir, Discharge measurement, Depth-Discharge relationship.

I. INTRODUCTION

Discharge measurement is meant to be one of the important purposes of a broad crested weir. Problems incurred with the implementation of the weir on the field were about its calculations. And since venture-flume was a better substitute for the complete discharge measurement, weir construction was seldom implemented. In our research we are emphasizing on the designing and construction of a Compound Broad Crested Weir (CBC Weir) and its utilization to know the depth discharge relationship according to the submergence ratio (or its total depth of submergence).

A stepped weir is combined into a curved one to overcome the drawbacks of a stepped weir. Thus the depth discharge relationship is to be derived to know the actual discharge passing through an open channel by its depth. The derivation of the depth discharge relationship is carried out by a model study of a deigned weir and testing its suitability on a tilting flume at different discharges.

The depth discharge relationship is to be implemented in knowing the discharge value by a compound broad crested weir. Thus by just knowing the depth at any section of a canal where the weir is to be installed, the discharge value can be obtained thus making the measurement simple and easy for different uses.

II. LITERATURE SURVEY

The characteristics of the flow over broad crested weirs with different throat cross sections have been of interest to many investigators. Hall (1962) derived an expression for the free flow characteristics of square edged broad crested weirs using boundary layer and verified his expression by using experimental data. Harrison(1971) derived an expression for coefficient of discharge for a streamlined broad-crested weir based on critical flow theory, allowing boundary layer development. Boiten and Pitlo(1982) carried out and experimental investigation on triangular broad-crested weirs with different apex angle. They found that broad crested weirs with a triangular cross section have a larger modular ratio than the weirs with a rectangular cross section. Bosted (1984) and Bos(1989) presented necessary head-discharge equations for broad-crested weirs and long throated flumes of various cross sections in the control device. Hager and Schwalt (1994) proposed broad-crested weirs as standard discharge measurement structures provided that a few certain conditions are satisfied. The governing equations are obtained by applying the energy equation between the head measurement section, when the fluid is considered ideal or frictionless. Chyan Den Jang(1943), carried out experiments on various CBC weirs in comparison with simple weirs and even derived dimensionless discharge equations. M Gogus, concluded that the discharge coefficient values obtained from the experiments performed on CBC rectangular weir are lower than those of simple rectangular broad crested weir having the same crest height and crest length. Hanna Majcherek(1984) carried out the theoretical and experimental investigations of effect of weir submergence whose experiments showed that coefficient of discharge is a function of nappe head. B. P. Tullis, J.C. Young and M.A. Chandler (2007) carried out experimental study to find head discharge relationship for submerged labyrinth weir, in which with the help of Villemonte's relation they derived the new dimensionless submerged head discharge relationship. G.A. Hinge (2015) carried out study on hydraulic jump type energy dissipater; the design of this weir is in reference with this research.

III. METHODOLOGY

A. EXPERIMENTAL MEASUREMENT OF DISCHARGE

The discharge measurement procedure for the computation of the discharge experimentally can be described with the following steps. The design discharge range for the weir used was 2lps to 6 lps. The discharge is set in the tilting flume after placement of the weir by trial and error method. The fabricated tank is used for knowing the volume (60 lts) and according to the time recorded minimum discharge is set.
Weir is placed in the tilting flume at the testing section and water is allowed to pass though the weir. Depth at required section viz. the upstream side of the channel before the submergence of weir, the depth at the upstream side of thecurve, the depth at the downstream side of the curve and the depth at the downstream side of the channel is measured with depth measuring device. The water is allowed to pass through the complete channel and the time required to fill the tank of 60 liters is recorded. This process is repeated for increment of every 0.2 lps of discharge.

Accordingly the discharge can be measured with the formula:

Discharge(Q)=(Volume (V))/(Time(t))

In the next set, the depth at the downstream side is adjusted by plank arrangement. The depth measurements are taken at all four required sections for every 0.2 lps of increment in discharge (upto 6 lps).

Discharge and its time required to fill the tank is noted and accordingly the discharges are calculated for different submergence.

B. THEORITCAL MEASUREMENT OF DISCHARGE

The flow at the upstream and downstream side of the weir is measured by allowing the water to flow through the tilting flume.

For measuring the theoretical discharge following process was adopted:

Calculate submergence ratio:

Submergence =(Downstream Depth-Starting Height)/(Upstream Depth-Starting Height)

Use of Ville-monte Equation to calculate the theoretical discharge:

$$Q_2 = Q_1 \left[1 - \frac{{h_2}^p}{h_1}\right]^{0.385}$$

Where,

h_2 = downstream depth – starting height
h_1 = upstream depth – starting height
p = 1.5 for rectangular Weir cross section
Q_1 = Free open channel Discharge
Q_2 = Submerged Discharge

Calculate Q_2 with respect to the above equation. Q_1 has to be calculated with respect to the number of submerged steps.

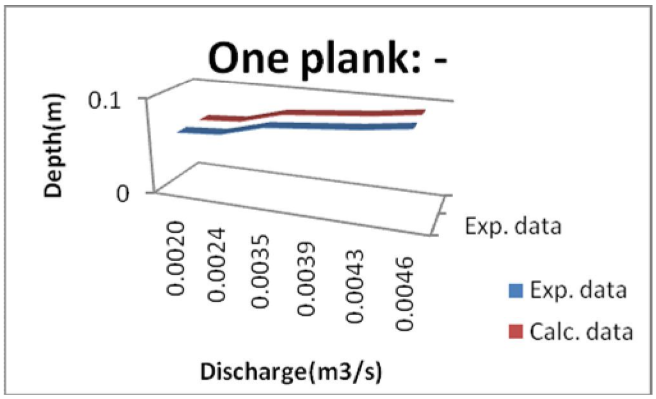
IV. RESULT AND DISCUSSION

A. FOR NO PLANK CONDITION

Upstream depth	Experimental discharge	Calculated discharge
(m)	(m^3/s)	(m^3/s)
0.062	0.0020	0.00211
0.067	0.0024	0.00238
0.078	0.0034	0.00315
0.083	0.0039	0.00356
0.0884	0.0045	0.00393
0.091	0.00477	0.00425

B. FOR ONE PLANK CONDITION

Upstream depth	Experimental discharge	Calculated discharge
(m)	(m^3/s)	(m^3/s)
0.064	0.0020	0.0021
0.067	0.0024	0.0023
0.079	0.00345	0.00295
0.083	0.00386	0.00314
0.087	0.00431	0.00344
0.093	0.00462	0.00386

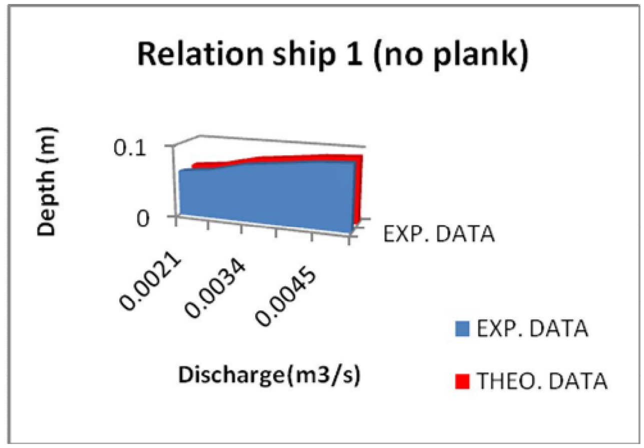


The investigation and their graphical representation suggested that the experimental and theoretical results show similar graphical profile. This suggested a possibility of deriving a relationship between depth and discharge which would overcome this discrepancy.

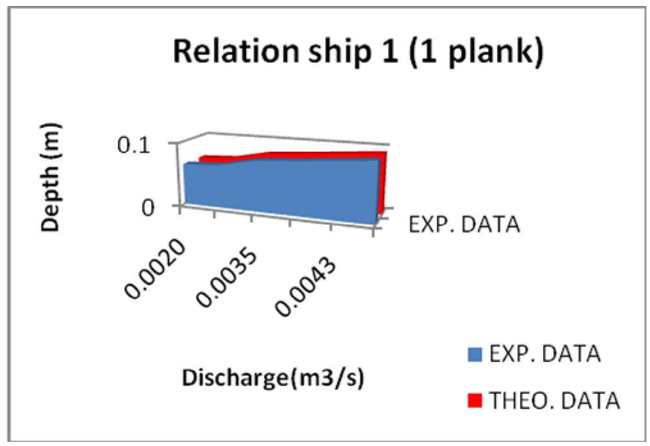
The analysis of the first set of readings led to development of two different relationships:

The first set of relationships developed is: -

$$Q_{EXP} = \frac{Q_{CAL}}{\left[1.57 - \frac{C_2}{C_1}\right]^{1.5}}$$ ….No plank condition



$$Q_{EXP} = \frac{Q_{CAL}}{\left[1.55 - \frac{C_2}{C_1}\right]^{1.5}}$$ …. One plank condition



V. QUANTITY SURVEY

The designed weir was tested in the experimental tilting flume and its volumetric analysis was done. Considering the conventional flow measuring device i.e. Venturi-flume which was a predesigned flume for the same experimental set-up. The volumetric analysis for the above mentioned discharge measuring devices is as follows:-

A) Volume of the Venturi-flume = 9263.98 cm^3
B) Volume of designed CBC Weir = 683.315 cm^3

Considering the Scale of 1:15 for the conversion of the dimensions of experimental devices to the actual site conditions, the total volume of two devices will be as follows:-

A) Volume of the Venturiflume = 31.26 m^3
B) Volume of designed CBC Weir = 2.306 m^3

For the Cost estimation of the discharge devices we have considered □5000/- for 1m3 RCC work

A) Cost of actual flume = Rs1,56,300/- approx
B) Cost of actual weir = Rs11,530/- approx.

Thus the net saving by implementation of the CBC weir is Rs1,44,770/-

We can arrive at a conclusion that the total saving in the cost is 92.62% which is far way economical than the conventional methods.

VI. CONCLUSION

The results of analysis are presented above and following conclusions were drawn:

- From the initial comparative analysis of data suggests that the experimental and theoretical values do have similar graphical profile.
- Thus we have also concluded from the two trials of our equation, that except for a few readings the relation is valid and is within the allowable discrepancy of 8%.
- We have also verified the economy of weir over flume in open channel flow and has a cost saving of almost 90%.

VII. FUTURE SCOPE

Investigating further & finding out the best possible result/ relation to perfectly match up with all the set of readings. Developing and researching on making the weir reliable for lowest value of discharges also. Investigation of the designed weir on an actual channel flow for its suitability and verification for the calculation of the discharge through the channel by the empirical equation.

VIII. ACKNOWLEDGMENT

We are thankful to Dr. G. A. Hinge & the Department of Civil Engineering of TSSM's Bhivarabai Sawant College of Engineering and Research, Narhe Pune, for guiding and providing facilities for the research work in their Hydraulics lab.

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