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Broad-Crested Weir as a Device for Measurement of Discharge

Bashir. M[1], Dr. Manal M. A. Albayati[2]

[1]Student, Department of Civil Engineering, Infrastructure University Kuala Lumpur (IUKL), Malaysia
[2]Head of Postgraduate Programme, Department of Civil Engineering, Infrastructure University Kuala Lumpur (IUKL), Malaysia

ABSTRACT

Weirs are overflow structures, which alter the discharge so that flow rate can be calculated, flood can be prevented, or even make a body of water more navigable. Measurements of discharge are known based on the surface profile of the water. For estimation of discharge over the weir, weir coefficient is required. In this report only the broad crested weir is focused on. Design and the analysis of this weir are shown in the report. It was found that the broad-crested weir is best for measuring discharge in small medium channels. Flow over a broad-crested weir is highly dependent on the weir's geometry, it's a useful hydraulic tool which enables engineers to control water height, velocity, and most importantly they can be used to calculate discharge. Hydraulic structures such as weirs, flumes, and pipes, may cause the flow upstream of the structure to rise above the normal flow depth this is a common property.
Keywords: Broad-Crested Weir; Discharge Coefficient, Open Channel Flow

I. INTRODUCTION

Weirs are known hydraulic structures used for measurement of discharge or to control the water elevation at outflows from channels and basins. Broad crested weir operates under the theory that critical flow conditions are created above the weir. When a weir is known as broad crested when it has horizontal crest with infinite length towards the direction of the flow. [1]. A broad crested weir is a weir with a crest, which is sufficiently wide to prevent the jet from springing clear at the upstream corner. The acceleration of the water as it flows on the weir crest causes a reduction in surface level. Flows in broad crested weirs are always assumed to be a critical flow.

Weirs are called "Broad" only when streamlines of the flow are in parallel to the crest and the distribution of the pressure is hydrostatic. A lot of some useful empirical equations of discharge for these weirs have been proposed. Gonzalez [10] performed an experiment in a flume using a full-scale broad-crested weir. Detail velocity and the pressure measurements were performed for two configurations. The results obtained showed that the rapid flow distribution at the upstream end of the weir, while an overhanging crests design affects the flow field. Percy [1] performed an experiment and his results show that the influence of the weir inflow designs on the bottom pressure distributions and discharge coefficient. The discharge equation over a weir cannot be exactly derived, due to the flow pattern of one weir is different from the other, but the flow pattern for a given weir varies with the discharge.

Unlike sharp-crested weirs which happen to be too fragile and cannot be considered reliable when gauging structures in open channels, especially when is come to irrigation.

II. METHODS AND MATERIAL

Literature Review

Hossein S.H performed an experiment, using a rectangular broad crested weir, which comprises of much geometry. The reason behind this experiment is to investigate the coefficient of discharge (cd) in the rectangular broad crested weirs. Furthermore relationships of present results with various experts study have been finished. The investigation was finished in an examination flume that was made of glass with a cross portion 0.3 m, 0.5 m 4.8 m in length. Water was supplied from a broad significant sustaining dish provoking a sidewall centered engaging a particularly smooth. The weirs have comprised of a 0.038 m stature, 0.30 m width, with an upstream-adjusted corner 0.0134m and 0.187m and 0.336m long level flat peak individually. Consequence of dimensional examination, the outcomes show that the dimensionless parameter of h1/b ought not be overlooked in mathematical statements deciding the release coefficient of the weir. The present results likewise demonstrated a slight increment in discharge coefficient with expanding head above peak like past studies. Extraordinary understandings between the conscious qualities and the qualities enrolled from the judicious numerical explanation are procured.

Zbyněk Zachoval performed an experiment on Discharge coefficient of a rectangular sharp-edged broad-crested weir his studies focused on the determination of the relationship for calculating of coefficient of discharge in a free overflow over the rectangular sharp-edged broad crested weir. The experiments were carried out in the laboratory of water management research at the institute of water structures at the faculty of civil engineering at the Brno University of technology, in a flume of B = b = 1.003 m and the thickness t = 0.500m. The determination was made on the premise of new estimation in a scope of the relative thickness of the weir from 0.12 to 0.30 and recently in an extensive scope of relative tallness of the weir to a great degree from 0.24m to 6.8m which significantly grows the application potential outcomes of low weirs. Furthermore, the impacts of erosion and surface strain on the estimation of the discharge coefficient were assessed and additionally the impact of the relative thickness of the weir. The new condition for discharge coefficient, communicated utilizing the relative tallness of the weir, was subjected to check made by a free lab, which affirmed its exactness.

Farzin S. and Dalir A.H performed an experiment on the discharge relations for broad crested weir. The reason for this study is to examine coefficient (Cd) in compound rectangular wide peaked weirs with various geometry measurement like: step statures (z), weir widths (b) and weir lengths (L) utilizing exploratory physical models. Impact of stream withdrawal because of establishment of weirs in the flume is explored for Cd as well. The investigations were directed in a flat rectangular channel 25 cm wide and 70 cm high with vertical plexiglass sides.. The compound weirs are of P=10, 13 and 16 cm; length L=30, 35 and 40 cm; lower weir peak width b=6, 8 and 12 cm and step stature of model cross segment z=9 cm were constructed (15 physical modes) and were situated at 5 m downstream of the inlet, and different components to enhance the methodology stream were given upstream of the weir. Results demonstrate that brokenness happens in head-release evaluations on the grounds that the segment width all of a sudden changes shape, encountering a break in slant when the stream enters the external segment. The release coefficient, (Cd), tends to increment when H1/L increments. Estimations of Cd got from the analysis were performed on the weirs are lower than those of a weir with a rectangular cross area for $H1/L < 0.27$ in view of its withdrawal impacts.

Formulas for calculating Discharge Coefficient are as shown below;

The discharge coefficient can be obtained experimentally as a function of the dimension total head of the approaching flow or as a function of various parameters.

The effect of rounding the upstream corner of broad crested weir is to increase the discharge for given head. If the upstream corner of the weir is so rounded as to prevent contraction entirely, and if the slope of the crest is as great as the loss of head due to friction, flow occurs at critical depth, and the discharge is given by different formula. Many researchers have studied the head discharge relations and characteristics of broad crested weirs. The broad-crested weirs are used to measure stream discharges.

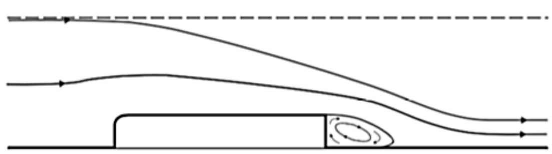

Figure 1: General characteristics of flow

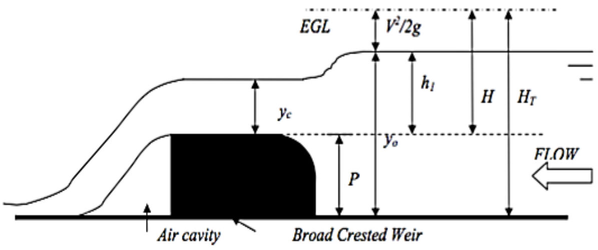

Figure 2: Broad crested weir with round entrance transition

III. RESULTS AND DISCUSSION

The equation below represents the actual flow rate over a broad crested weir:

$$Q = Cd\sqrt{g}.b\,(\frac{2}{3}H)^{\frac{3}{2}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.(1)$$

From equation $Cd = \dfrac{Q}{1.705 \times B \times H^{1.5}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots.(2)$

Where,

- Q = Actual flow rate (m^3/s)
- C_d = Discharge Coefficient
- g = Gravity
- b = Breadth of weir
- y_o = Upstream water depth
- y_c = critical depth
- h_1 = Upstream head
- H = Total energy head (m)

Coefficient discharge (cd) is the upstream energy head **(HI),** and the length of the weir crest in the direction of flow (L). As shown in the equation below:

$$Cd = 0.93 + 0.10\,H1/L \qquad \ldots\ldots\ldots\ldots.(3)$$

The error of Cd in broad-crested weir, which has been constructed with reasonable care and skill, can be deduced from the equation (Bos 1985).

$$\mathbf{X} = \pm\left(3\left|\frac{H1}{L} - 0.55\right|^{1.5} + 4\right) \text{Percent} \ldots\ldots\ldots.(4)$$

For all weirs, independent of their shape the head–considering the critical flow above the crest derives discharge relation for modular of flow.

$$Q = V_C \cdot A_c \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..\ldots\ldots..(5)$$

Where

$V_C =$ *is the mean velocity*

$A_C =$ *area of flow at critical section*

The proportion of inertial powers to gravity strengths speaks to the impact of gravity upon the condition of stream. The proportion is named as Froude number as characterized as just inertial power separated by gravitational power. $Fr\,\dfrac{v}{(gL)^{\frac{1}{2}}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.$ (6)

Where

V = Mean velocity of flow in m/sec

g = acceleration of gravity in m/sec^2

L = Characteristic length in m

IV. CONCLUSION

Weirs have been designed and used extensively in hydraulic structures to control the flow depth and discharge. To estimate the discharge over the weir, a weir coefficient is required. The discharge coefficient can be obtained experimental by functions of the nondimensionl total head of the approaching flow or as a function of various parameters. Although weirs can occur naturally, for the context of engineering design, the discussion will center on the equations used in the design of hydrologic/hydraulic facilities. From the characteristics of the broad crested weir, it is found that its the simplest device for flow measurement; it is also more suitable for large discharges. The width of the weir is taken as the width of the waterway. If the characteristics of the weir are known, the discharge can be evaluated from the equation.

NOTATION

B = Width
C = coefficient of discharge
F = Froude number
g = Acceleration of gravity
h = height of water surface
H = energy head
H1= Upstream total head measured
HT = Total energy head of upstream flow

P = Broad crested weir height.
b = Weir width, it.

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