MILITARY INSTITUTE OF SCIENCE AND TECHNOLOGY

DEPARTMENT OF EWCE

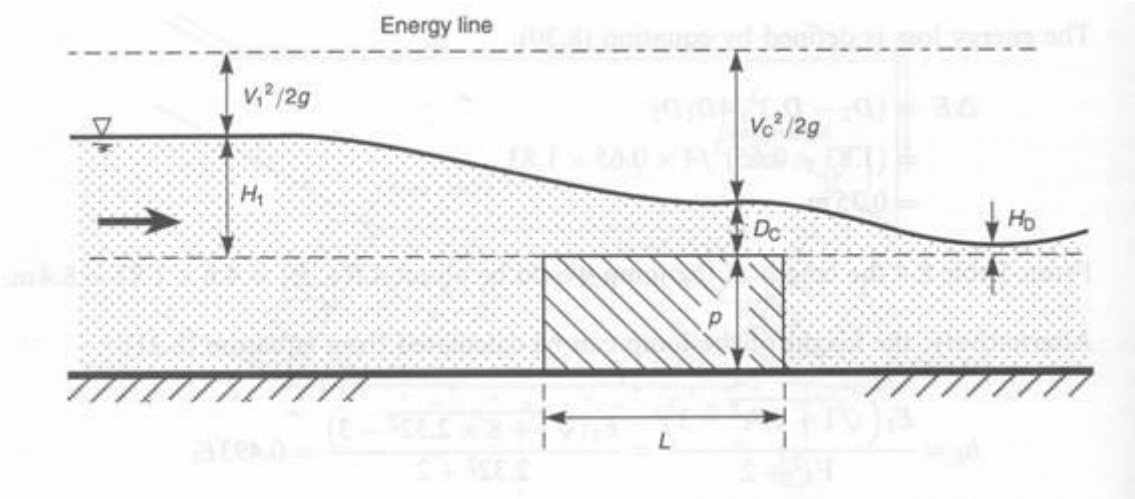
EWCE 362: Open Channel Hydraulics Sessional

Experiment No. 2

FLOW OVER A BROAD CRESTED WEIR

2.1 General

Weirs are the structures consisting of an obstruction such as a dam or bulkhead placed across the open channel with a specially shaped opening or notch. The weir results an increase in the water level, or head which is measured upstream of the structure. The flow rate over a weir is a function of the head on the weir.



BROAD CRESTED WEIR

Common weir constructions are the rectangular weir, the triangular or v- notch weir, and the broad-crested weir. Weirs are called sharp-crested if their crests are constructed of thin metal plates, and broad-crested if they are made of wide timber or concrete.

A Broad crested weir is an over flow structure with a truly level and horizontal crest. It is widely used in irrigation canals for the purpose of flow measurement as it is rugged and can stand up well under field condition. But practically some problem arises with the weir as there exists a dead water zone at the upstream of the weir and the head loss is more comparable to other devices. This experiment deals with measurement of discharge using the broad crested weir and also calibration of the weir.

2.2 Practical applications

Broad crested weirs are robust structures that are generally constructed from reinforced concrete and which usually span the full width of the channel. They are used to measure the

discharge of rivers, and are much more suited for this purpose than the relatively flimsy sharp crested weirs. Additionally, by virtue of being a critical depth meter, the broad crested weir has the advantage that it operates effectively with higher downstream water levels than a sharp crested weir.



Broad crested weir in Albion, Michigan

2.3 Theory

Consider the broad crested weir shown in fig.2.1 if there is no significant energy loss, according to Bernoulli's equation,

$$H_1 = y_1 + \frac{v_1^2}{2g} = H = y + \frac{v^2}{2g}$$

$$H_1 = y + \frac{v^2}{2g}$$

$$v = \sqrt{2g\,(H_1 - y)}$$

So, theoretical discharge,

$$Q_t = Av = A\sqrt{2g\,(H_1 - y)}$$

Provided the critical flow occurs at control section ($y - y_c$), then

$$Q_t = B\,y_c\sqrt{2g\,(H_1 - y)} \quad \text{.....(2.1)}$$

Where, B is the width of the weir. Now, for a rectangular channel section there exists a relationship between total head and depth of flow as $H = \frac{3}{2}y_c$. Hence putting $y_c = \frac{2}{3}H$, Eq. 2.1 stands as,

$$Q_t = \left(\frac{2}{3}\right)^{1.5}\sqrt{g}B\,H_1^{1.5} \quad \text{.....(2.2)}$$

2.2.3 Coefficient of discharge:

Due to some assumption taken in the derivation of the governing equation, the theoretical discharge and the actual discharge always varies from each other. So coefficient of discharge is introduced. If Q_a is the actual discharge, then, the coefficient of discharge, C_d is given by,

$$Cd = \frac{Q_a}{Q_t}$$

Then, $Q_a = C_d \left(\frac{2}{3}\right)^{1.5} \sqrt{g} B H_1^{1.5}$ .....(2.3)

Coefficient of discharge for the broad weir is depends on the length of the weir and whether the upstream corner of the weir is rounded or not. Normally, in a field installation it is not possible to measure the energy head H_1 directly and therefore the discharge is relate to the upstream depth of the flow over the crest, y_1 in the following way,

$$Q_a = C_v C_d \left(\frac{2}{3}\right)^{1.5} \sqrt{g} B y_1^{1.5} \quad \text{.....(2.4)}$$

Where, $C_v$is the correction coefficient for neglecting the velocity head in the approach channel. Generally the effects of the C_v is considered in C_d and finally the governing equation stands as,

$$Q_a = C_d \left(\frac{2}{3}\right)^{1.5} \sqrt{g}\, B\, y_1^{1.5} \quad \text{.....(2.5)}$$

And

$$Q_t = \left(\frac{2}{3}\right)^{1.5} \sqrt{g}\, B\, y_1^{1.5} \quad \text{.....(2.6)}$$

2.2.4 Calibration:

Calibration means development of a define relationship between water depth and discharge of a flow measuring structure. For broad crested weir there is a relationship between upstream depth and discharge, i.e. $Q = ky_1^n$. This relation is named as calibration equation. So calibration deals with determination of k and n and development of equation $Q = ky_1^n$. The plotting of the calibration equation is known as calibration curve. There are two different ways to develop a calibration equation. They are –

1. Plotting best fit line by eye estimation
2. Developing best fit line by regression

By eye estimation:

As, $\log Q = N \log y_1 + \log k$ so, if Q and y_1 are plotted in a log-log paper, the graph will represent a straight line. So, different set of Q and y_1 are plotted in log-log paper keeping y_1 in X axis and Q in Y axis. The best fit line is drawn by eye estimation. The slope of the line gives the value of n. Then for any value of y_1, Q and n the value of k can be found form the equation $Q = ky_1^n$

By regression:

$$Q = ky_1^n$$
$$\Rightarrow \log Q = \log k + n \log y_1$$

Let, $\log Q = Y$, $\log y_1 = X$, $\log k = K$
So, $Y = K + nX$

Then,

$$n = \frac{N(\sum XY) - (\sum X)(\sum Y)}{N(\sum X^2) - (\sum X)^2}$$ Where, N = Number of data

$$\text{And } K = \frac{(\sum Y) - n(\sum X)}{N}$$

The correlation coefficient is given by,

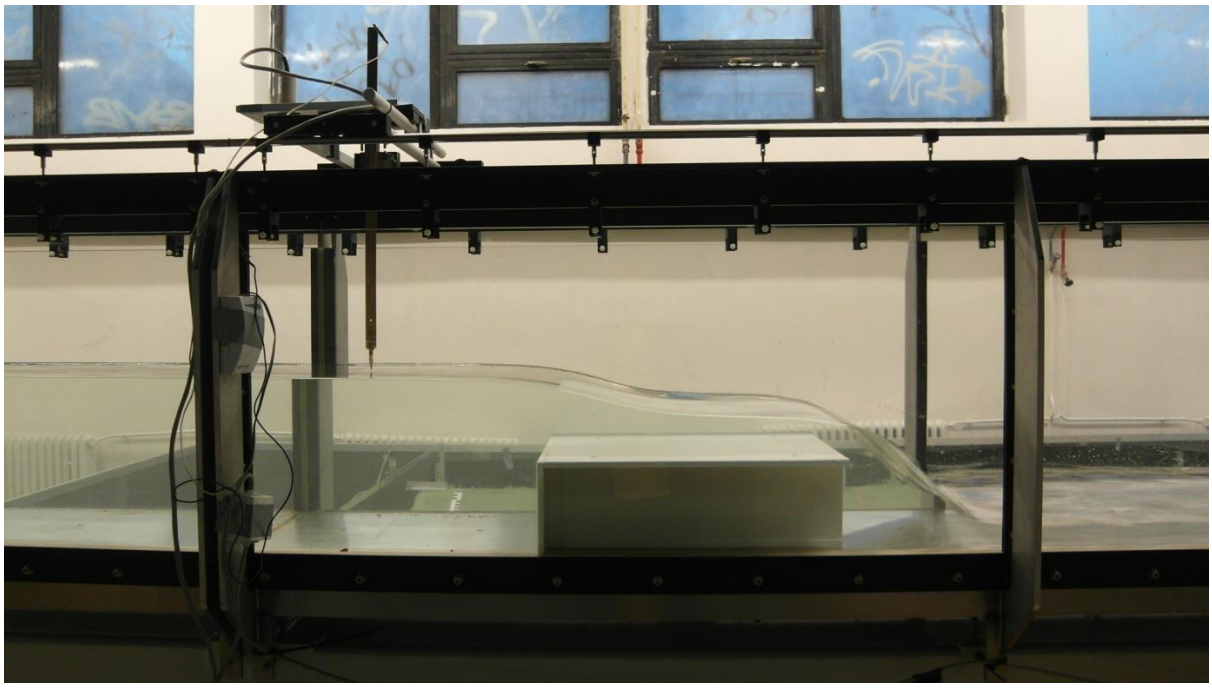
$$r = \frac{N(\sum XY) - (\sum X)(\sum Y)}{(\sqrt{N(\sum X^2) - (\sum X)^2})(\sqrt{N(\sum Y^2) - (\sum Y)^2})}$$

For a perfect correlation, r = 1.0, if r is between 0.6 and 1.0 it is generally taken as a good correlation.

2.4 Objectives

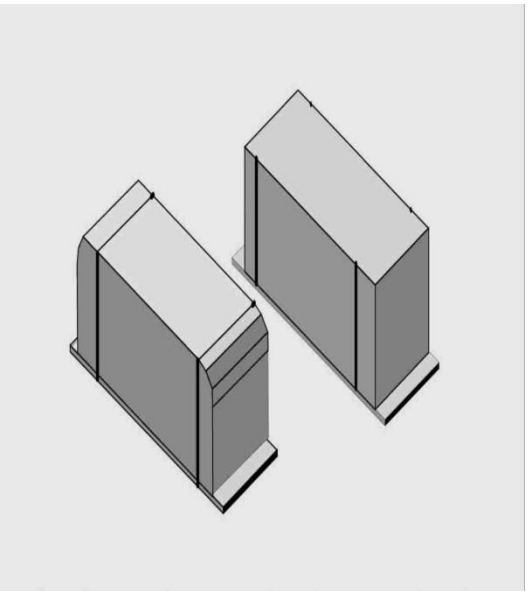
1. To determine the theoretical discharge of the weir.
2. To measure the actual discharge and hence to find out the coefficient of discharge.
3. To calibrate the weir.

2.5 Experimental setup:

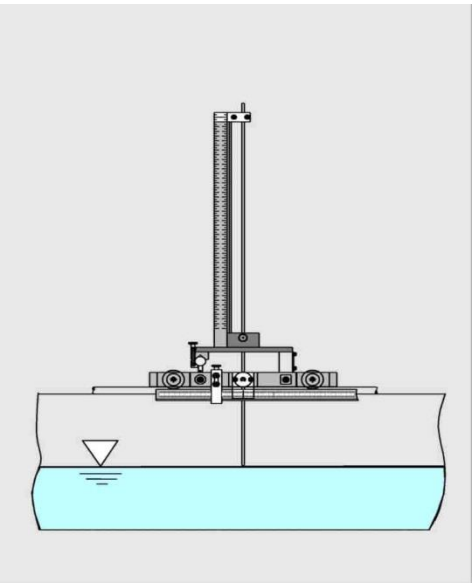


2.6. Apparatus

Flow channel, Broad crested weir, instrument carriage etc.



Broad crested weir



instrument carriage



Flow channel

2.7 Procedure

Determining actual discharge and coefficient of discharge:

1. Measure the upstream water level over the weir y_1 at three points, then find the average depth and determine the theoretical discharge using eq. 2.6
2. Take the reading of actual discharge and hence find the coefficient of discharge.

Calibrating the weir:

By eye estimation (should be done by students having odd student number):

1. Plot actual discharge against different upstream depth of flow over the crest in a log log paper and find the value of n and k as discussed in article 2.2.4
2. Develop the relation $Q = ky_1^n$

By regression (should be done by even student number):

1. For a table having column Q, y_1, X, Y, XY, X^2 as discussed in article 2.2.4 (detailed given in calculation portion) and find the value of n, k and r.
2. Compare the equation formed by eye estimation method.

2.8 DATA SHEET

FLOW OVER A BROAD CRESTED WEIR

Width of the weir, B =

Group No	Depth Of Water Over Weir Crest y (m)	Actual Discharge $Q_a(m^3/sec)$	Theoretical Discharge $Q_t(m^3/sec)$	Coefficient Of Discharge $C_d = \frac{Q_a}{Q_t}$	Mean Coefficient Of Discharge C_d
1					
2					
3					
4					
5					
6					

Level / Term : **Dept. :**
Roll No. : **Section:**
Group No. : **Date :**

Signature of the Teacher

2.9 Calculation

2.10 Assignment

1. What are the advantage and disadvantage uses of broad crested weir?

2. Why is it necessary to calibrate the weir?

3. Broad crested weir designed so that $0.07 \leq H_1 / L \leq 0.5$. What does the upper and lower limit signify?

2.11 Discussion