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Experimental Evaluation Of One Shape Of Broad Crested Weir

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Certification

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Chapter One

Introduction

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INTRODUCTION

ABSTRACT

The discharge through irrigation canals is commonly controlled by means of gates. Depending on the downstream head, the gate opening and the upstream head the flow may be termed free flow or submerged flow. Sills may improve or disimprove the discharge characteristics of flow. The experiments were conducted on a small laboratory flume and sills of different heights were tested under wide range of flow conditions. The obtained predictions of the discharge coefficient using the developed equations are compared to the experimental data. The present developed equations proved good reliability and high accuracy.

1.1. GENERAL:

The weir is one of the oldest structures used to measure the flow of water in open channels, they are an overflow structures that are built across open canals. They are easy to construct and can measure the discharge accurately when correctly installed. However, it is important that the water level downstream is always below the weir crest; otherwise the discharge reading will be incorrect.

The water level upstream of the structure is measured using a measuring gauge, where the difference - the head - between the water level and the crest of the weir is marked 'H'. The discharge corresponding to that water level is then read from a table which is specific for the size and type of weir being used, or the gauge post can show the discharge directly.

Several rating equations were developed for standard rectangular contracted weirs by different investigators.

In the past, user organizations selected an equation, called it standard, and specified construction requirements and limitations of use. However, Kindsvater and Carter (1959) developed an improved method for computing rates of flow through rectangular, thin-plate weirs. Their method also applies to fully side suppressed, partially contracted, and fully contracted rectangular weirs. Kulin and Compton (1975) discuss the method and equation for rating fully contracted V-notch weirs with any angle between 25 degrees and 100 degrees. This method also rates partially contracted 90-degree, V-notch weirs.

The Kindsvater approach accounts for velocity of approach effects and the accompanying variation of discharge coefficient caused by changes of effective width and head. This method is preferred for calibrating or rating rectangular and triangular weirs. Also, this method will correct for excess approach velocity in standard weirs.

1.2. The aim of this study:

The experimental program done with the help of open channel flume in hydraulic laboratory (univ. of technology) in order to collect the hydraulic data for selected shape of broad crested weir and shows its effect on the initial & sequent depth of hydraulic jump ~~by~~ that resulting D/S of weir, also the coefficient of weir and influencing figures were extracted.

1.3. Definition of Weirs:

A measuring weir is simply an overflow structure built perpendicular to an open channel axis to measure the rate of flow of water. Inspecting and checking the critical parts of weir structures for degradation and improper operation are easy.

A properly built and operated weir of a given shape has a unique depth of water at the measuring station in the upstream pool for each discharge. Thus, weirs can be rated with respect to an upstream head relative to the crest elevation versus discharge, and equations or tables which apply to the particular shape and size weir can be generated. The crest overflow shape governs how the discharge varies with head measurement.

1.4. Advantages and limitations of Weir

1.4 .1. Advantages:

- Capable of accurately measuring a wide range of flow.
- Tends to provide more accurate discharge ratings than flumes and orifices.
- Easy to construct.
- Can be used in combination with turnout and division structure.
- Can be both portable and adjustable.
- Most floating debris tends to pass over the structure. Broad crested weir can be computer calibration

- The design and construction of structure is simple, thus it can be relatively inexpensive to install.
- A theoretical calibration based on post construction dimensions can be obtained, and the accuracy of the calibration is such that the discharge error is less than two percent.
- As with other open channel flow measurement structures operating under free flow conditions, a staff gauge which is marked in discharge units can be placed upstream; this allows a direct reading of the discharge without the need for tables, curves, or calculators.
- Submergence does not affect broad-crested weirs up to about 80 percent with a vertical downstream drop and up to about 90 percent with sloped downstream transitions.
- The head loss across the structure is usually small, and it can be installed in channels with flat slopes without greatly affecting existing upstream flow depths.
- In broad crested weir Floating debris tends to pass over and through the structure without clogging.

*1.4.2. **Limitations:***

- Relatively large head required, particularly for free flow conditions.
- The upstream pool must be maintained clean of sediment and kept free of weeds and trash; otherwise the calibration will shift and the measurement accuracy will be compromised. For water supplies with sediment, there will be deposing upstream of the structure.
- The upstream water depth will be somewhat higher than it was without the structure farmers and other water users tend to oppose the installation of this structure because they believe that it significantly reduces the channel flow capacity.
- In case of broad crested weir for water supplies with sediment, there will be deposing upstream of the structure.

*1.5. **Types of weirs:***

Weirs can be classified as below:

- Weirs are identified by the shape of their opening, or notch.
- The edge of opening can be either sharp or broad crested.

1.6. Broad-Crested Weirs:

A broad-crested weir is a raised overflow crest, commonly a flat horizontal block. However, a variety of crest shapes can be used to establish flow control in boundaries that are horizontal in the direction of flow. Broad-crested weirs often have special approach transitions ahead of and up to the crest surface, such as nose treatments like ramps and rounded corners. Crest length in the direction of flow is generally long enough, relative to the measuring head, to make the effect of flow curvature insignificant and short enough to prevent friction from controlling depths.

For discharge measurement let us assume that the flow on the weir is critical and the losses between the weir and the location where the upstream flow depth is measured are negligible. Then we may write the energy equation between these two sections as

$$H1 + V^2 / 2g = 3/2H \qquad (1\text{-}1)$$

in which H1 = upstream flow depth above the crest. By assuming the velocity of approach, V, to be negligible, this equation for the discharge per unit width, q, may be written as

$$q = 2/3H \sqrt{(2/3gH)} \qquad (1\text{-}2)$$

However, a general equation for the discharge may be written as

$$Q = C\,B\,\sqrt{g}\,H^{1.5} \qquad (1\text{-}3)$$

in which B = channel width and C is a coefficient introduced to take into consideration the effects of various simplifying assumptions. If (Z) is the height of the weir above the channel bottom, then V = Q/ [B (H + Z)].

Chapter Two

Instrumentation& measurement

CHAPTER TWO

Instrumentation and Measurement

2.1. *Weir height:*

One of the most important design parameters is the height of the weir above the upstream channel bed. This height should be sufficient to provide modular flow for the entire range of discharges that the broad crested weir is intended to measure; however, it should not be higher than necessary because this would cause undue increases in the upstream water level after installation. Thus, a design objective is to determine the minimum crest height for which modular flow can be obtained, and not to exceed this minimum height.

Excessively tall broad crested weirs are not a problem in terms of water measurement or calibration; they are only troublesome with respect to unnecessarily raising the upstream water level.

2.2. *Weir Submergence:*

Accurate measurements of submerged sharp-crested weir discharges cannot be made because of the spread of measured data when determining correction factors for drowned or submerged weirs. Skogerboe et al. (1967) show plots of correction factor curves for several weirs with actual data points plotted around them. The range of data spread of submergence corrected discharge is "15 percent. Besides complicated hydraulics, submerged weirs also have the problem of precision of head reading relative to head measurement. Despite the form of the correction procedures, discharge is actually based on the difference of two heads.
These differential heads are small relative to the ability to measure head precisely. Therefore, submergence correction procedures should be only a temporary emergency procedure to provide estimates. The need for submergence correction should be eliminated directly by maintenance and cleaning of weeds, sediment, and other debris from the downstream channel, changing system operations, raising the crest, or installing another kind of measuring device since correction estimates are only within +15 percent.

2.3. *Head Measurements:*

The head is usually sensed either in the channel itself or in a stilling well located to one side of the channel. The stilling well is connected by a small pipe to the channel. Many methods can be used to detect the water surface in a stilling well or in the flume channel. Measurement heads can also be determined with a variety of pressure sensing devices. The most frequently used methods are wall-mounted staff gages in the entrance section of the flume or in a stilling well or float operated recorders placed in a stilling well.

2.4. *Factors affecting head measurement:*

2.4.1. *Location for Head Measurement:*

The measuring station for short-form flumes must be installed as specified to match closely the location used when the flume was empirically calibrated. For example, the measuring station of a Parshall flume is in the convergence water surface drawdown. For long-throated measurement structures, the gauging or head-measuring station should be located sufficiently far upstream to avoid detectable water surface drawdown, but close enough for the energy losses between the gauging station and approach section to be negligible. This placement is particularly critical if the ratings are based on coefficient values in a discharge equation as discussed in Bos (1989). In the computer derived ratings, drawdown and friction losses caused by the gage location are an integral part of the calculation. Therefore, the gage should be located as indicated in the precomputed long-throated structure design and selected tables.

2.4.2. *Selection of Head-Measurement Device:*

The success or failure of the structure and the value of the collected data depend closely on the proper selection of a suitable head measurement device. The three most important factors that influence this selection are:
(1) Frequency of discharge measurement.

(2) Allowable error in the head detection.

(3) Type of measurement structure under consideration.

The usual expected reading errors in the sill-referenced head are listed in table for some common head measurement devices. The listed errors are higher than the expected random errors, partly to compensate for the effects of several systematic errors, such as zero-setting, instrument lag, reading error, temperature, and stilling well leakage. If no device with sufficient accuracy is found from this procedure, two choices are available:

(1) Allow greater error in the measured discharge for the minimum required head loss or

(2) Redesign the structure with a narrower bottom width, resulting in a higher value of minimum measurement head.

2.4.3. ***Gage Installation and Zero Setting:***

The most important factor in obtaining accurate discharge measurements is the accurate determination of the sill-referenced head, H1. The upstream sill-referenced head can be measured by a gage or recorder only if the observed water level is known with respect to the weir sill (or flume crest) level at the control section. The method used to set (zero register) the gage, recorder, etc., depends on the structure size, the flow rate in the channel during the setting procedure, and available equipment. Standard surveying techniques are practical for accurate setting of most wall or staff gages.

The canal side slopes usually only approximate the intended slope. Mounting sloped gages so that a selected scale reading in the most frequently used range of the gage coincides with the corresponding elevation for that reading will partially compensate for deviation from design slope. Thus, the greatest reading errors will occur in the flow ranges that are seldom used. If this procedure causes the zero end of the scale to be displaced by more than about 0.015 ft, the actual side slope should be determined for adjustments to the calibration. This determination also should be made if accuracy over the full flow range is required.

Several methods can be used to zero a water level recorder; three are particularly suitable. The recorder can be set:

(1) When the canal is dry.

(2) When water is ponded over the flume, or

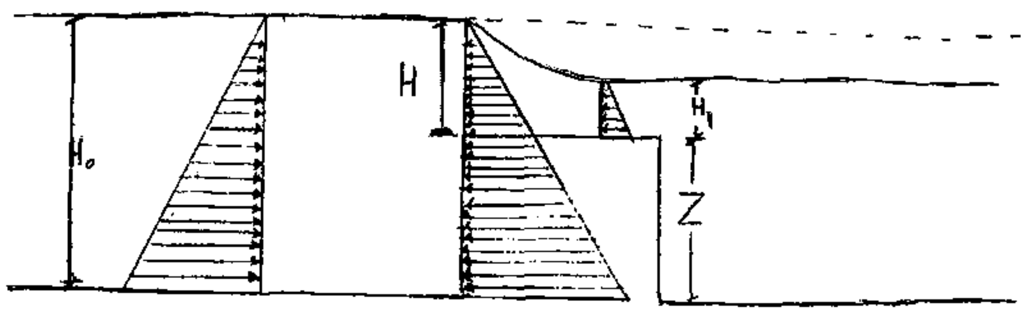
(3) When water is flowing through the flume. These zero-setting methods assume that the sill referenced elevation can be determined during the procedure. This determination is not always possible, especially on wide structures.

A stable and permanent surveying bench mark, such as a bronze cap placed in concrete, should be added in an acceptable location near the measuring structure. Its elevation should have been previously established relative to the sill elevation. More detailed information on zero-setting procedures is presented in Clemmens et al. (2001) and Bos et al. (1991).

2.5. Equation of broad-crested weirs:

The sharp crested weirs are not significant practically i.e it is usage with large channels will be unpractical, so that it must be use another structure made from bricks or concrete. The weir considered **broad-crested** when crest thickness is more than (60%) of the nappe thickness.

Depending on the height of the weir in relation to the depth of approaching channel. The discharge equation may be derived from the balance of forces and momentum between the upstream approach section and the section of minimum depth on the crest of the weir.



From the fig. above and for one unit width of the weir

$$\ell q \left(\frac{q}{H1} - \frac{q}{H^\circ}\right) = \left(\frac{\gamma H^{\circ 2}}{2} - \frac{\gamma H1^2}{2} - \frac{\gamma Z}{2}\left(2H^\circ - Z\right)\right) \quad (1)$$

$$H^\circ - Z = 2 \quad (2\text{-}2)$$

H1

From eq. (1) & eq. (2) we have:

$$q = 0.433 * (\sqrt{2g}) * \left(\frac{H^\circ}{H^\circ + Z^\circ}\right)^{0.5} * H^{1.5} \quad (2-3)$$

The total discharge will be:

Q =B *q

$$Q = 0.433 * (\sqrt{2g}) * \left(\frac{H^\circ}{H^\circ+Z^\circ}\right)^{0.5} * H^{1.5} * B \quad (2\text{-}4)$$

The term ($0.433 * (\sqrt{2g}) * \left(\frac{H^\circ}{H^\circ+Z^\circ}\right)^{0.5} * H^{1.5}$) represent the Influence of drag force, shape or dimension of crest and the upstream energy level. We may combine these influences to obtain **the metric weir coefficient M** so that:

$$Q = M\,B\,H^{1.5} \quad (2-5)$$

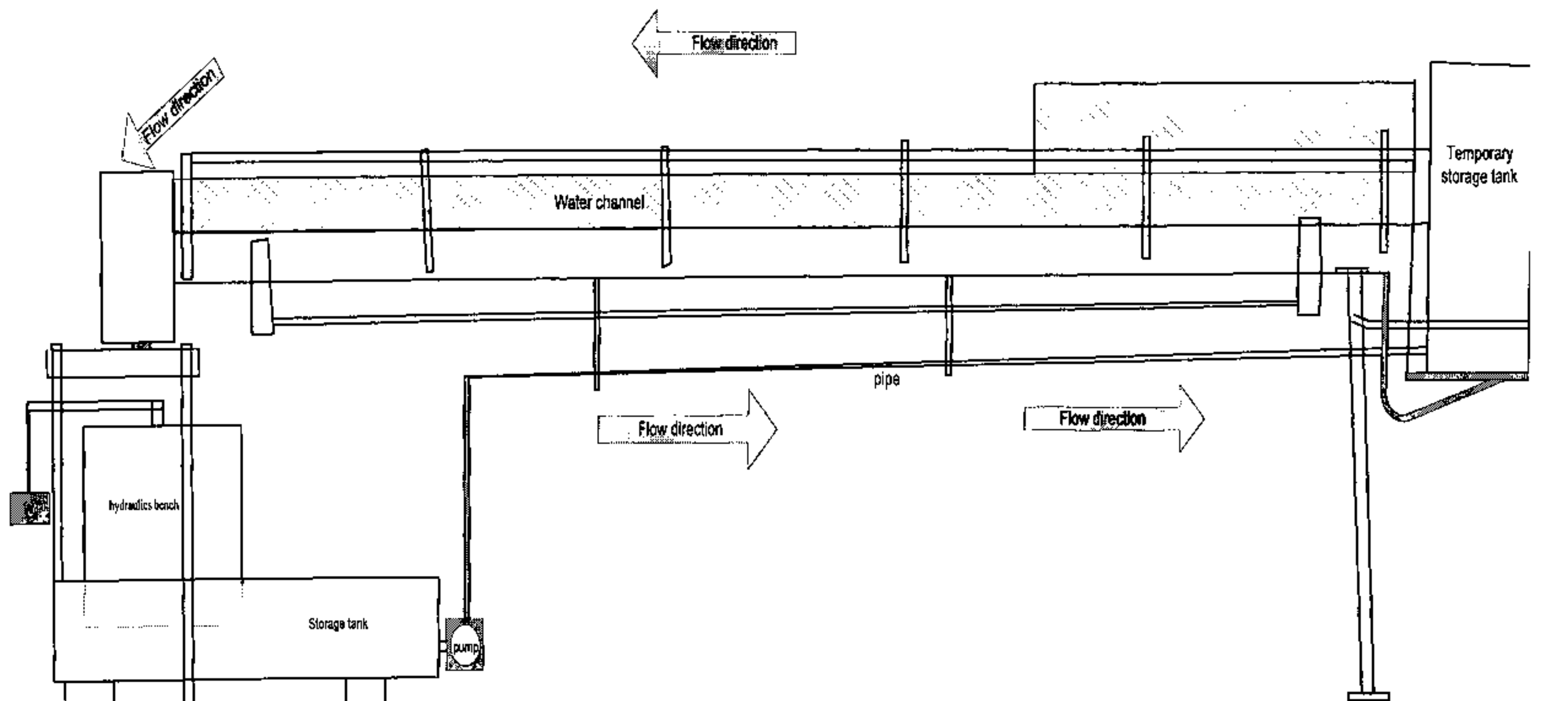


Fig (~~12~~) :The experimental chanel (where the wood model installed)
(1-2)

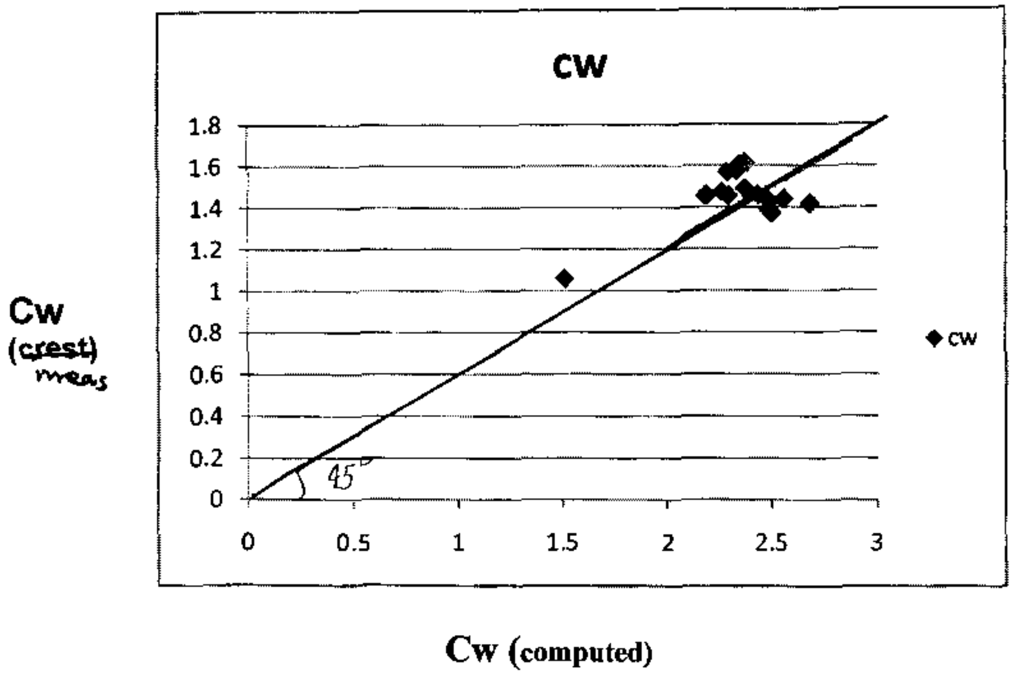
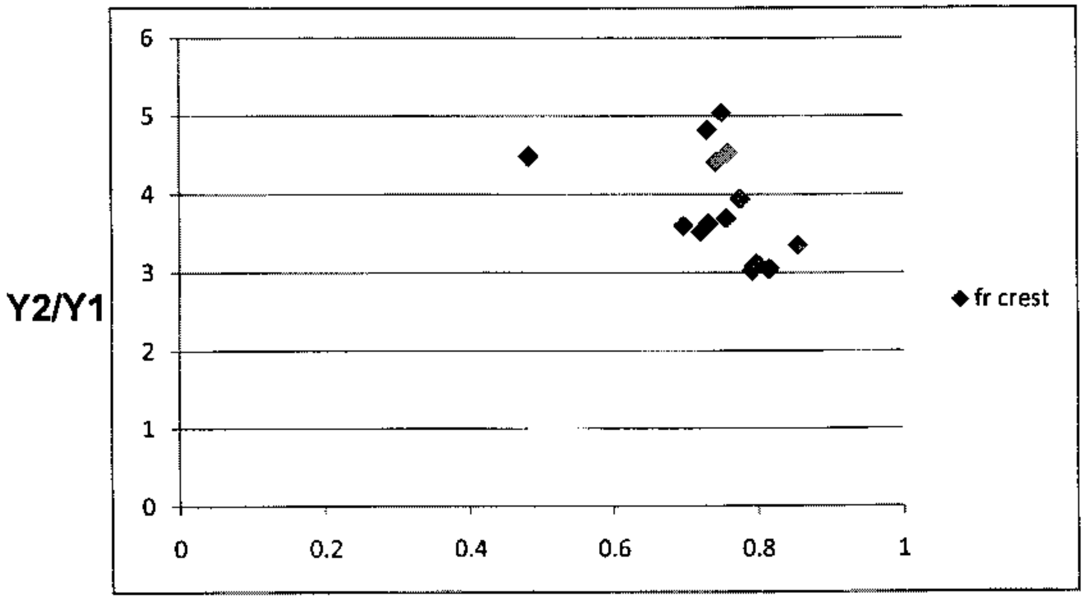


Fig. (3-1) shows the comparable between Cw computed & Cw (crest)

3.2. <u>Froud number effect:</u>

To understand the effect of Froud number on weir coefficient, two of the trapezoidal weirs were use and depending on the data collected from the laboratory measurement, we obtain that the higher value of Froud number gives higher value of weir coefficient as show in the fig.(2) below:

samp.	Q(measured)	H1(crest)	V(crest)	FR(CREST)	CW
	m3/sec.	cm	m/sec.		
1	0.000851	3.8	0.2946676	0.4826208	1.511613
	0.000798	2.73	0.3846154	0.7432088	2.327798
	0.00078	2.65	0.387289	0.7595878	2.379097
	0.000742	2.63	0.3712227	0.7308398	2.289057
	0.000728	2.55	0.375645	0.7510572	2.35238
2	0.000857	2.78	0.4056229	0.7767219	2.432764
	0.000808	2.72	0.3908669	0.7566759	2.369978
	0.000773	2.7	0.3767057	0.7319573	2.292558
	0.000754	2.68	0.3701885	0.7219732	2.261286
	0.000737	2.7	0.3591618	0.6978687	2.185789
3	0.000854	2.6	0.4321862	0.8557556	2.680305
	0.000793	2.6	0.4013158	0.7946302	2.488855
	0.00082	2.65	0.40715	0.7985405	2.501102
	0.000809	2.64	0.4032097	0.7923089	2.481584
	0.000805	2.58	0.4105467	0.8160527	2.555952



Fr (crest)

Fig. (3-5) shows the relationship between the (Y2/Y1) &Fr(crest)

3.5. Conclusion:

The investigation shows different factors affecting the weir coefficient then the discharge. The first factor was Froud no. plotted vs. **Cw** (fig. 3-2) which gives a good relationship that gives high value of **Cw** through the decreasing in **H1** value which represented the depth of water above the crest of weir.

Fig. (3-3) shows that for three samples, the small one gives a high value of **M** which mean that's when the weir height decreasing the depth above the crest decreasing and affect the value of **M** and that lead to increase the discharge.

Fig.s (3-4) & (3-5) shows no any relationship between (Y2/Y1) on the fr no. &(H1/P) that's mean the height of sill has no effect on the hydraulic jump characteristics.

APPENDIX

Notation:

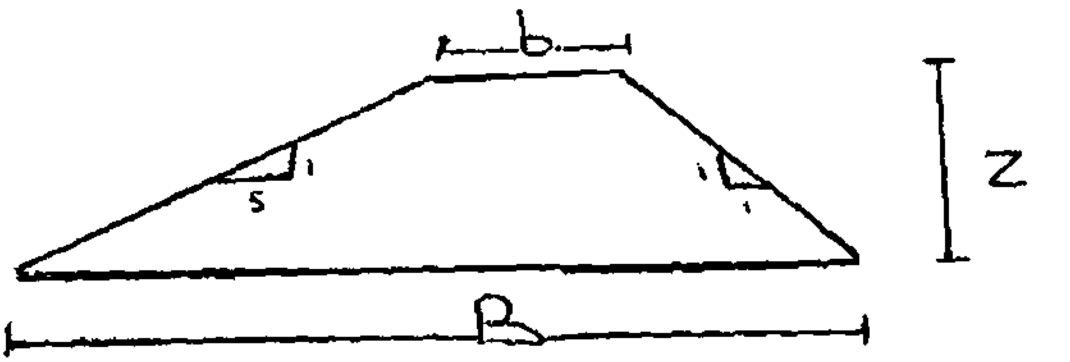


Fig. (1) Shows the shape of weir that tested

Where:

B: bottom width of the weir

b: top width of the weir (crest width)

z: weir height

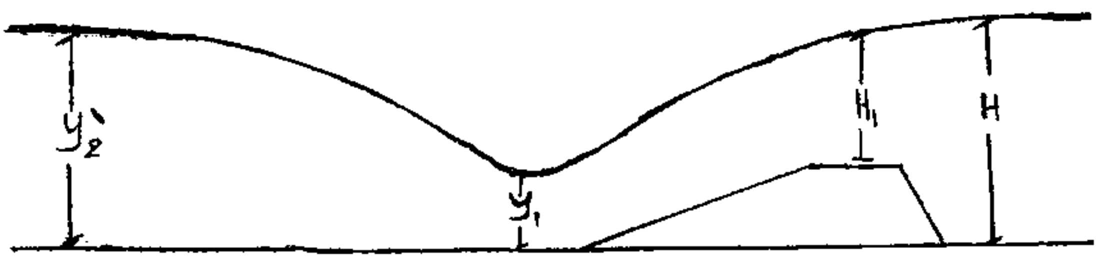


Fig. (2) Shows the water surface profile over weir

Where:

Upstream water depth: H0

Fig. (4) Shows the depth of water over crest

References: