The Pharma Innovation Journal 2022; 11(2): 115-118

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; 11(2): 115-118

www.thepharmajournal.com
Received: 14-12-2021
Accepted: 22-01-2022

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Studies on critical depth and coefficient of discharge (C_d) in semi-circular crested weir

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Abstract
At the Hydraulics Laboratory, the current study was carried out in a hydraulic flume with a motorized bed slope change equipment, College of Agricultural Engineering, Bapatla. The main objective was to design semi-circular crested weir and determine the flow characteristics of critical depth, location of critical depth for different co-efficient of discharges for critical flow conditions. Two weirs with three different discharges (12 l/s, 14 l/s, and 6 l/s) and three depths(18.5 cm, 14 cm and 7.8 cm) were used in the experiment. The results indicate that the distance of critical section from the crest will not be constant for lower discharges and also observed that the distance of critical section from the crest has been reduced with increase in discharge for both the crest heights. The co-efficient of discharge was found to be higher with higher discharges for both the models and the co-efficient of discharge was found to higher for smaller diameter semi-circular weirs.

Keywords: Coefficient of discharge (c_d), critical depth, hydraulic flume, weir, crest height

Introduction

Water is a precious and exhaustible natural resource and has also been recognized as an economic good. Efficient water control in irrigated agriculture calls for correct size and alertness of water. The accurate water measurements are to be done to avoid wastage of water due to excess irrigation. The strategies to be had in open channel hygrometry are using hydraulic structures (devices), velocity-area methods and dilution methods. The hydraulic structure technique is best suited for low discharge measurements in open channels. The hydraulic structure used to dam up a stream or river, over which the water flows, is called a weir. It provides a simple and accurate means of measuring water. Water flowing over weirs is characterized by a rapidly varied flow region near the crest. The broad- crested weir, the sharp-crested weir, and the circular- crested weir are the three most prevalent forms of weirs. Circular-crested weirs have a higher discharge capacity than broad and sharp-crested weirs, hence semicircular crested weirs were considered for research. Previously, experiments were carried out in a rectangular wooden flume on broad-crested weirs of various types. It has been observed that the location of critical depth varied with the shape of the weir and with the head (Woodburn *et al.* 1932) [7]. The experiments shown that the depth, near the end of the crest is less than two-thirds of the total head for any type of crest irrespective of its length. (Satyanarayana and Satyanarayana *et al.* 1993) [6]. It was also observed that modified broad crested weirs are much tolerant to submergence condition up to 75% level without any change in the flow characteristics. Some experiments on some flow characteristics of trapezoidal broad crested weirs with crest lengths of 15cm, 20cm and 25 cm revealed that critical depth occurs at only one point with all crest lengths (Sai *et al*. 1993) [5]. Location ratio increases with increase in crest length. Location of critical depth moves towards upstream side with increase in crest length. Under varying submergence situations, studies on some flow properties of semi-circular contraction critical flow flumes for modest discharges and observed that the drop in the water surface profile in the throat of the flume is more abrupt with increasing contraction (Krupavathi *et al.* 2008) [4]. The water surface profile takes flatter shape with increasing submergence. The site of critical depth is not found in the throat section at all discharges for all flumes at the highest submergence condition of 90%, showing that the side contracted flumes are vulnerable to higher submergence circumstances. Some experiments were conducted to evaluate the reliability in flow measurements with a cut-throat flume and a broad-crested weir in free and submerged flow conditions as compared to a standard V notch (Ahmad *et al*. 1991). Cut-throat flumes can be employed with a –2.2 to 8.6% inaccuracy for free flow circumstances, according to the findings.

The percent inaccuracy in flow Measurements ranged from –3.2 to 14.6 percent under submerged flow circumstances. With a percent error of –1.5 to 5.8%, broad-crested weirs should be used. Some limitations for the construction and placement of weirs are described as head should not be less than 0.2 ft and not to be greater than 2 ft, the head of a rectangular or Cipolletti weir should not exceed one-third of the length of the weir, and the weir length should be chosen so that the head for design discharge is near the maximum (Smajstrla and Harrison 1981).

Materials and Methods

Experimental Setup

A hydraulic flume with motorized bed slope alteration facility installed in Hydraulics laboratory of College of Agricultural Engineering, Bapatla was used in the experiment. The highest flow available is 22 l/s due to a practical constraint of flow regulation in the laboratory. As a result, flows of 22 l/s, 14 l/s, and 6 l/s were planned to conduct. Two circular crested weirs with 30 and 50 cm diameter having crest height 15 and 25 cm were made of babul wood with a fine finish and coated with a uniform roughness across the entire piece to avoid damage from water immersion (Fig. 1)

The models of circular weirs were installed in hydraulic flume by fixing the weir with bed of hydraulic flume at a distance of 372 cm from head gate of hydraulic flume. A color wax was applied between the weir and side walls of flume to prevent the water leakage and to resist the velocity of flow. Both weirs were placed at the same distance from the gate of the flume.

Fig 1: Installation of Circular Crested Weir

Experimental procedure

After flow stabilization, the circular crested weir-1 was attached to the hydraulic flume's side walls. The water surface profile was taken with a point gauge. The depth of water level was kept at 18.5, 14, 7.8 cm by operating a valve. The water surface levels were measured at every 2cm intervals along the centre line of the hydraulic flume by moving the point gauge on the rails while maintaining a steady discharge. With the remaining two discharges, the process of recording the water surface profiles was repeated of 14 lit/sec, and 6 lit/sec and depth14 cm, 7.8 cm and same procedure was followed for circular crested weir-2.

Computation of Critical Depth

The following equation was used to find the critical depth for different discharges and weirs.

$$Y_c^3 = \frac{Q^2}{gB_c^2} \quad (1)$$

Where, the subscript 'c' relates to critical condition.

Y_c = Critical depth
Q= Volume rate of flow
G=Acceleration due to gravity
B_c = Width of the flume

Coefficient of discharge (Cd)

For various discharges and weirs, the following discharge equation was used to calculate the co-efficient of discharge (Cd).

$$Q = \frac{2}{3} C_d L \sqrt{2g} H^{3/2} \quad (2)$$

$$Q = KH^{3/2}$$

Where $K = \frac{2}{3} C_d L \sqrt{2g}$

Results and Discussion

The critical depth has been found to occur at only location in the throat for all heads. The critical depth for different discharges was computed.

Table 1: Location of Critical Depth for Different Weirs and Discharge

S No	Discharge(lit/sec)	Critical Depth (cm)	The critical depth is measured from the weir's centre	
			Weir-1	Weir-2
1	22.0	8.2	1.0	1.5
2	14.0	6.0	5.7	4.0
3	6.0	3.5	7.5	6.0

Relationship between Crest height and Distance of Critical Section from the Crest

It was observed that the distance of critical section from the crest was not varied much with the crest height for the highest discharges of 22.0 lit/sec (Fig. 2). But for low discharges of 6.0 lit /sec and 14.0 lit/sec the distance was reduced from 7.5 cm to 6.0 cm and from 5.7 cm to 4.0 cm with increase in crest height from 15 cm to 25 cm respectively. This indicates that the distance of critical section from the crest would not be constant for lower discharges.

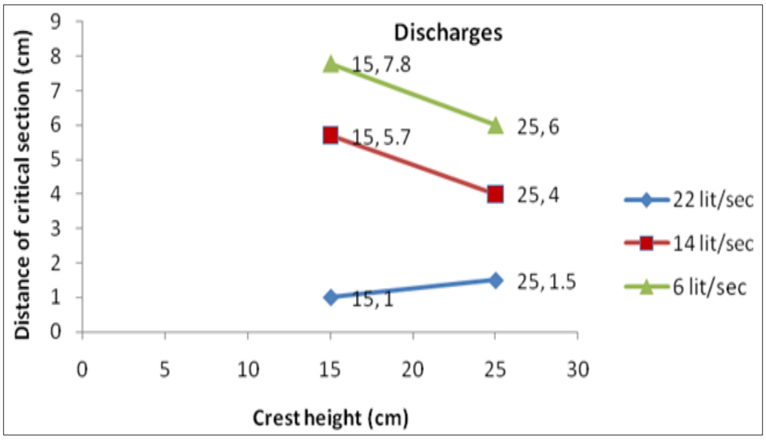

Fig 2: Relationship between Crest height and Distance of Critical Section from the Crest

Relationship between Discharge and Distance of Critical Section from the Crest

It was observed that the distance of critical section from the crest has been reduced with increase in discharge for both the crest heights (Fig.3). For the crest height of 15 cm, the distance was reduced from 7.5 cm to 1.0 cm with increase in discharge from 6.0 lit/sec to 22.0 lit/sec. Similarly, for the crest height of 25 cm, the distance was reduced from 6.0 cm to 1.0 cm with increase in discharge from 6.0 lit/sec to 22.0 lit/sec. It was concluded that the location of critical section would be nearer to the crest section for higher discharges.

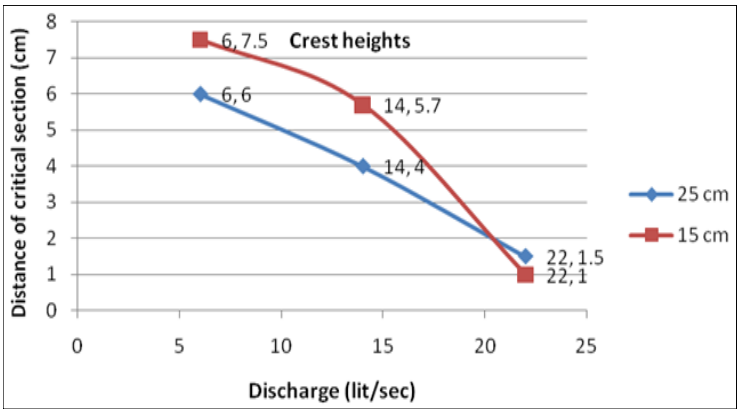

Fig 3: Relationship between Discharge and Distance of Critical Section from the Crest

Table 2: Variation of Co-efficient of Discharge (Cd)

S. No	Discharges (lit/sec)	Upstream depth, H (cm)		K		Cd	
		Weir-1	Weir-2	Weir-1	Weir- 2	Weir-1	Weir- 2
1	22.0	10.5	11.5	0.65	0.56	0.73	0.63
2	14.0	9.7	9.9	0.46	0.45	0.52	0.50
3	6.0	6.6	5.6	0.35	0.45	0.40	0.50

The co-efficient of discharge was found to be higher with higher discharges for both the models and the co-efficient of discharge was found to higher for smaller diameter semi-circular weirs (Table 2).

Conclusions

From the foregoing results, the following conclusions could be drawn.

- For all potential conditions evaluated, critical depth occurs in only one spot in the throat area and hence occurrence of critical section was ensured.
- Both the designs (weir-1 and weir-2) were acceptable since the critical flow conditions are ensured within the throat sections.
- With a decrease in discharge, the critical portion moves downstream from the crest.
- As the diameter of the weir increases, the critical portion moves upstream towards the crest.
- The co-efficient of discharge (Cd) was found to be higher (0.73) with higher discharges for both the weir designs.
- The co-efficient of discharge was found to be higher for smaller diameter semi-circular weirs.

References

1. Ahmad S, M Yasin, Ahmad MM. Flow measurement with portable cut –throat flume and broad crested weir in flat gradient channels. Irrigation and drainage systems 1999;5(2):141-150.
2. Castro Orgaz O, Giraldez JV, Ayuso JL. Critical Flow over Circular Crested Weirs. Journal of hydraulic Engineering, ASCE. 2008;134(11):1661-1664.
3. Document-AE25 Agricultural and Biological Engineering. Institute of Food and Agricultural Sciences. 1-6.
4. Krupavathi K. Some flow characteristics of semicircular contraction critical flow flumes for low discharges under different submergence conditions. Unpublished M.Tech thesis submitted to College of Agricultural Engineering, Bapatla, ANGRAU. 2008.
5. Sai SSV, Sastry, KM Reddy. Some flow characteristics of a trapezoidal modified broad crested weir. Unpublished thesis submitted to College of Agricultural Engineering, Bapatla, ANGRAU. 1993.
6. Satyanarayana TV, Satyanarayana T. Flow Characteristics of modified trapezoidal broad crested weirs for low discharges, Indian Journal of Agricultural Engineering. 1993;3(1-2):39-46.
7. Wood JG. Tests of broad crested weirs. Transactions of ASCE. 1932;96(1):12-16.