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The effect of crump weir's geometry changes on hydraulic flow characteristics: A review

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Abstract – Water is one of the natural resources that man has known since ancient times and relied on daily. Its availability is an urgent necessity to sustain life and achieve human development. It is the prima food source for many people who live near the river and depend on fishing and agriculture for their livelihood. Therefore, dams are built across rivers to store water and create an artificial lake behind the dam to provide and utilize water and increase the discharge. The current studies focus on one of these types of weirs, the crump weir. Some of these studies deal with adding changes to the geometric shape, such as adding holes with different numbers, changing the height, making the weir in a V-shape, and changing the angle of inclination before and after the weir using artificial intelligence technology. The results showed an increase in the discharge coefficient (Cd) and the flow energy dissipation.

Keywords – Crump Weir, Roughness Surface, Angle Inclination, Discharge Coefficient(Cd). Opening Holes, Modular Flow, Energy Dissipation

I. INTRODUCTION

The weir is one of the most significant hydraulic components utilized to control and regulate discharge. They have multiple uses, the most important of which are irrigation, electric power generation, and flood control, also in improving river navigation [1], [2], [3]. Many types of weirs depend on the geometrical shape of the weirs, the most important of which are Broad Crested Weir, Sharp-crested weir, V-notch sharp-crested weir, Trapezoidal-shaped (Cipolletti) weir [4]. When there is a lack of available head of water above the weir, other options besides the rectangular submersible weir include the short-crested weir, Ogee weir, and Crump weir [5]. With a triangular cross-section, it is referred to as level a V-three-sided profile weir. [6] ,[7]. This type of wastage was developed in some countries which depend on fish for their livelihood—one of the solutions of fish gathering Fig. 1 [8],[9].

II. CRUMP WEIR

An English structural architect (Edwin Samuel Crump) was the first who design this type of weir [11]. A Crump weir is a two-dimensional triangular weir shaped like a triangle in the streamwise order and has a horizontal crest in the transverse direction. The upstream slope is 1:2 while the downstream slope is 1:5 to 1:2, respectively [7],[12]. Compared to previous long-based weirs, they offered a more extensive modular range and a more predictable performance under submerged situations [13]. The main benefit of using a crump is making the discharge coefficient of the flow constant and stable during the modular flow. Also, the structures are not affected by non-modular flow [14]. The crossing point of the two slanting surfaces shapes an even straight peak at the right moments to the stream course in the methodology stream channel. The rise may either be made of painstakingly adjusted and joined substantial segments or have a cast-in non-corrodible metal profile. Crump weirs are utilized as

Fig.1. Keep fish from passing the waterway [10].

estimating structures in open channels. They enjoy the benefit that the coefficient of discharge is unsurprising and that the downstream bed heights affect the particular cut-off points and the measured coefficient for one of every two upstream and one out of five downstream slanting appearances. The upstream slope was made to stop silt accumulation from reaching the summit. Under modular flow circumstances, the downstream slope was shallow enough to enable a hydraulic jump to develop on the weir, serving as an inherent energy dissipator and reducing losses under submerged conditions. It is not possible to obtain an exact equation for calculating the discharge passing over the weir because the flow pattern differs from one weir to another, as the flow pattern changes with the discharge [15]; consequently, Eq (1) is the equation for calculating the discharge across Crump Weir [6].

$$Q = Cd\ B\ g^{½}\ H^{3/2} \qquad (1).$$

III. MODULAR FLOW (NOT SUBMERGED FLOW)

This type of flow occurs when the water level downstream crump weir is not affected by the water level upstream of the weir Fig.2.Therefore, it is easy and possible to measure the flow passing over the weir individually [16],[17].

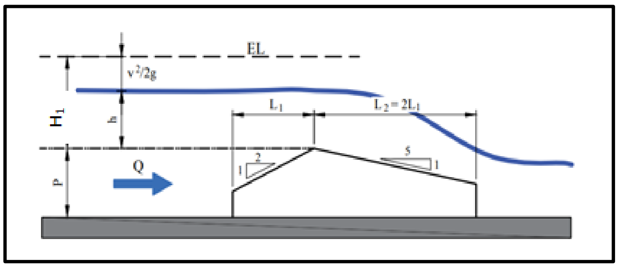


Fig. 2 sketch for Crump weir through modular flow condition[16].

IV. NON-MODULAR FLOW (SUBMERGED)

This flow type occurs when the water depth downstream of the weir is influenced by the water depth upstream. To ascertain the discharge that crosses over the weir's crest in these flow conditions, the water level must be monitored both upstream and downstream [18]. Fig.3. To prevent this occurrence, the water depth behind the weir must be 75% lower.

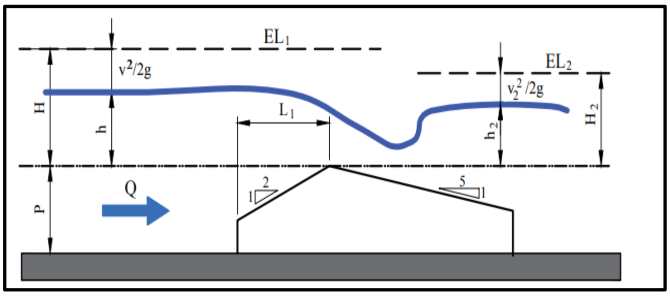


Fig. 3 sketch for Crump weir through non-modular flow condition[16].

V. APPLICATION STUDIES

Several studies have been conducted for the runoff over the weir type -crump, and a change in the traditional weir's geometry was carried out to improve the performance of the weir. Investigating the influence of height and surface roughness on the discharge coefficient (Cd) and flow parameters over the weir can be considered the first investigation on this type of weir (crump weir). Therefore, the researcher [19] conducted laboratory experiments using three dams of different heights, and for each model, three types of roughness were used for the dam surface. The obtained results showed that the values of the discharge coefficient (Cd) would increase with the increase in discharge and decrease with the decrease in the dam's height. Also found, the increase in the surface roughness leads to an apparent reduction in the discharge coefficient values (Cd) Fig. 4.

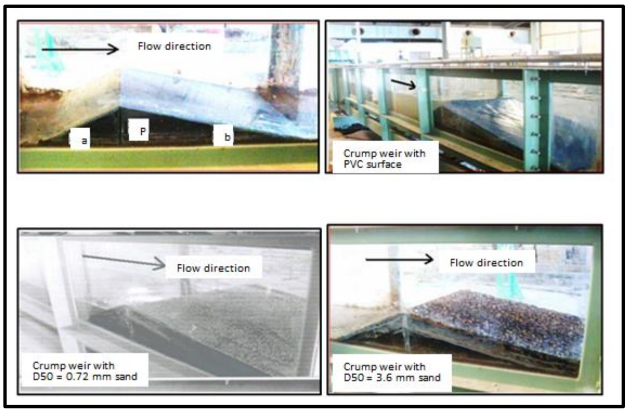


Fig.4 flow over three crump weirs [19].

[20] concentrated on the impact of longitudinal stream openings (openings) entering both downstream and upstream sides of the crump weir evenly, acting as energy dissipators and releasing coefficient additives. [21] concentrated on a standing slanted peak Crump weir. He reasoned that at obdurately huge heads, the weir acts as one portion of a level V- Crump weir for the same cross-over peak slant. At lower heads, the stream cross segment turns out to be unequivocally unbalanced with a critical reduction in release coefficient esteem. [22] concentrated on altering the peak of the crump weir to be Angular as opposed to an ordinary crest. They utilized Four crump weir models made of wood. Each model included a portion of a triangle with a flat base longitudinally symmetrical. Length of base L= 78.5 cm, the width of weir B= 29.5 cm, and the height of crest P= 20 cm; however, they differed by the level of the center peak, P, which was shown by models 1, 2, 3, and 4 as 20, 17.5, 15 and 12 cm, respectively, in Fig. 5

Eight stream rates, five stream profundities, and constant state-secluded stream conditions were applied to the three angular peaked crumps and the typical crump. The findings demonstrated that, in contrast to model 1 of P'/P=1, the values of the upstream approach Fraud number (Fr) dropped with decreasing (p') for models 2, 3, and 4, respectively, due to a reduction in flow velocity and an increase in flow depth with decreasing p'. The weir's effectiveness in dissipating flow energy reduces at a relatively low (Fr). Models 3 and 4 demonstrate this, and as a result, there is reduced energy loss. Similar energy dissipation was shown in Fig. 6 for Model 2 with (P'/P=0.875) and Model 1 (P'/P=1).

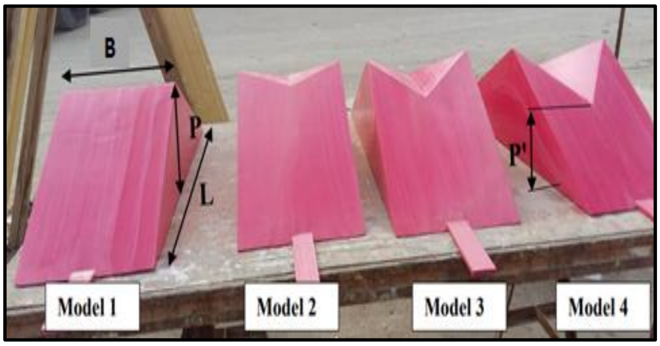


Fig. 5 Crump Weir traditional and models [22].

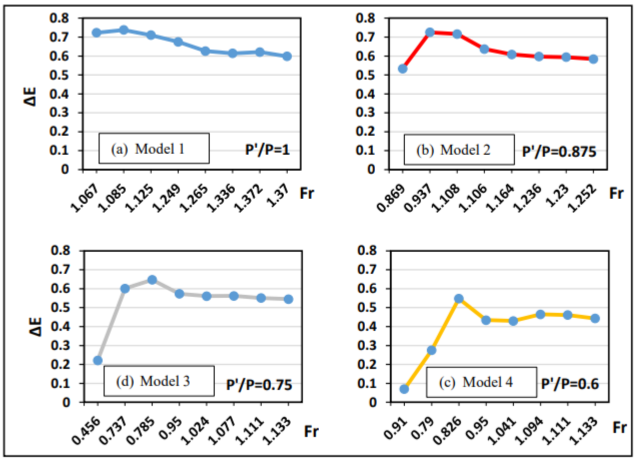


Fig. 6 the relation between ΔE and Fr for (a) model 1, (b) model 2, (c) model 3, and (d) model 4[22].

[5] considered the connection between the pace of the stream and upstream head over crump weir other than acquiring a rough free surface profile in an unstable open channel stream. In the researcher's study [20], [10] a new performance of the Crump-type weir was used by placing holes in the body of the traditional weir to know the effect of these openings on the discharge coefficient(Cd) and the dissipation of the energy of flow Fig. 7.

The laboratory experiments showed that the discharge coefficient(Cd) increases by increasing the number of openings from one to two and three openings, at a rate ranging from 10,11,13 %, respectively (Fig. 8.

The results showed that the best behavior of the flow is in the case of a weir with two holes, compared to the case of one and three holes, because the flow is more stable. Furthermore, the progress stream system has fewer dangers .and the maximum dissipation in the energy of the flow is in the case of using two holes in a body. Growling; The results also showed that using three holes in the weir is unstable and difficult to install in the channel Fig. 9.

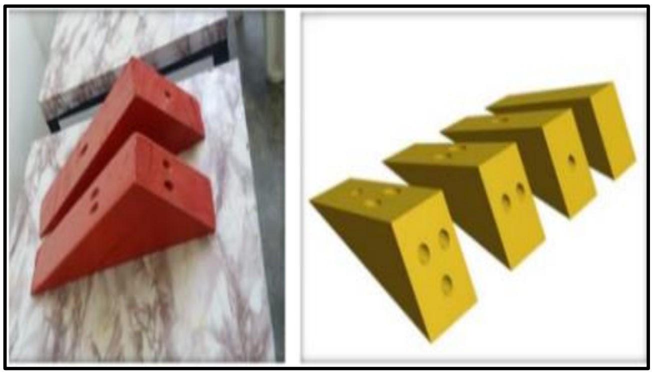


Fig. 7 Physical models of crump weir[20].

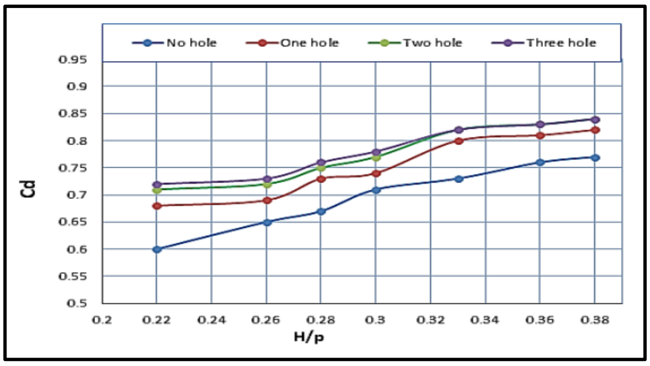
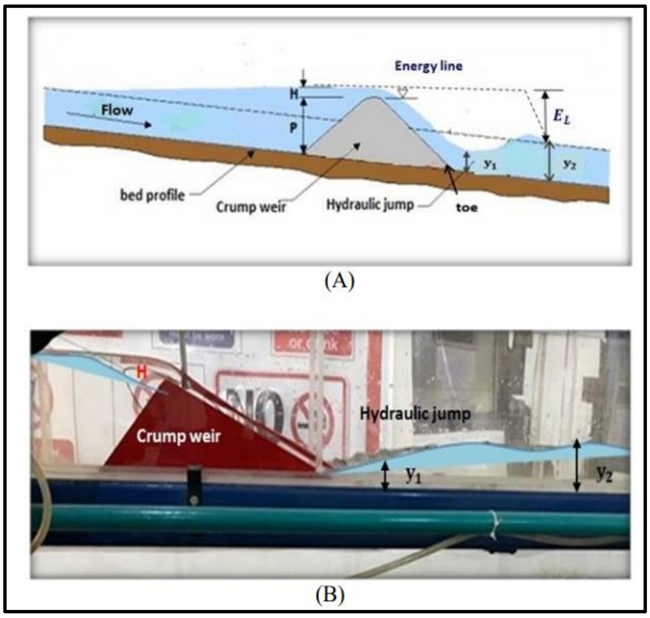


Fig. 8 the relationship between discharge coefficient (Cd) and the ratio of H/P for the models [20].

[23] concentrated on the way of behaving of crump weirs under different cross-over peak inclines, he presumed that for the was presumed that for a similar cross-over peak incline, the construction acts as one portion of level V weir at moderately enormous heads.[24] He evaluated the alignments performed on the Crump weirs; he showed that the exact activity of ump weirs is plausible in non-standard Circumstances.[5] contemplated the connection between the pace of the stream and upstream head over crump weir other than getting a rough free surface profile in a thin open channel stream [25]. He demonstrated that the coefficient of release varies with the value of the absolute strength by using the example of a stream and the coefficient of release in open channels and a water treatment facility for Crump Weir (TS). [26] studied the crump weir's height, the weir's angle upstream on the discharge coefficient(cd), and the flow characteristics that pass over the weir. The (FLOW 3D) program was also used to conduct new experiments. Laboratory experiments were conducted using an artificial channel, the researcher used 15 physical models, five different angles of upstream the weir 17o, 22o, 27o, 32o and 37o, and three heights of the weir 10, 15, and 20 cm, under different conditions of flow Fig. 10.



(A)

(B)

Fig. 9 The hydraulic jump appearance: (A) Theoretical sketch of hydraulic jump; (B): The model in the reality of the hydraulic jump method [20].

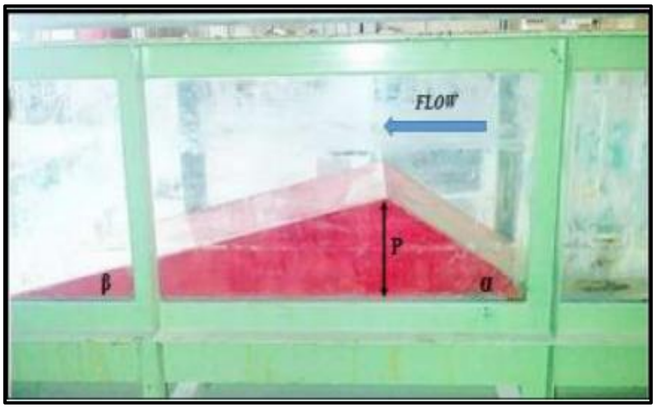


Fig. 10 physical model of crump weir[26].

The study's results also showed that as the angle ahead of the weir increases, the discharge coefficient's value drops. It was noticed that by increasing the rise from 27o to 32o and from 27o to 37o, the value of the discharge coefficient decreases by 5.1 % and 7.2 %, respectively. While at the reduction in the angle from 27o to 22o and from 27o to 17o, the value of the discharge coefficient increases by 1.5 % and 3.7 %, respectively Fig. 11.

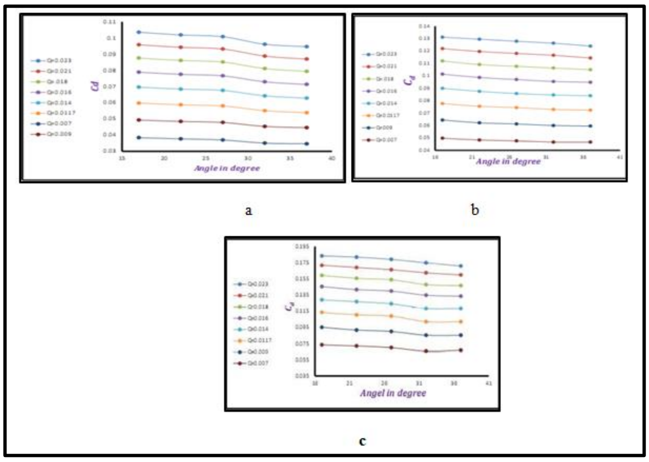


Fig. 11 relationship between (Cd) and upstream angles [26].

The researcher [27] studied the application of artificial intelligence techniques in estimating the discharge coefficient using eighteen physical models of the crump weir; they used different crest angles with a value of 80, 90, 100, 110, 120, and 130°, different angles for the inclination of upstream weir with a decreasing value of 85, 70, 55, 40, 25 and 10 and various tips for downstream of the weirs with an increasing value of 15, 20, 25, 30, 35 and 40, as shown in Fig. 12. The findings indicate a perfect agreement between the laboratory values and the values using artificial intelligence techniques. Cd's value depends on a crump weir's upstream, crest, and descending angles. When the summit slope rises from 80 to 130, the downstream angle rises from 15 to 40, and the upstream angle falls from 85 to 10, the Cd falls.

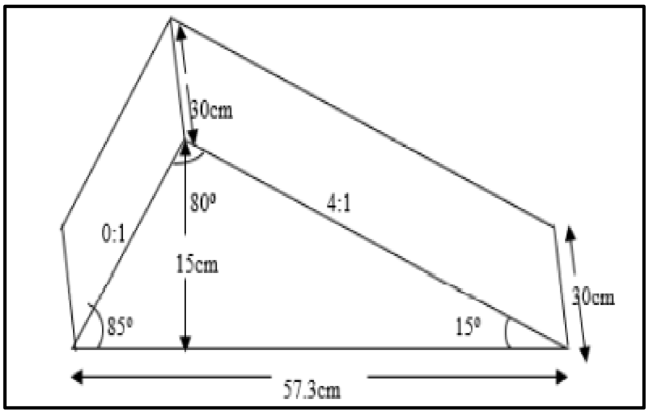


Fig. 12 sketch crump weir model 1 [27].

In the researcher's study [28], he used low-cost physical models to provide safe passage. For fish in England and Wales, hydraulic measures included the erection of slotted baffles with different numbers, arrangements, and arrangements. The researcher [29] used triangular weirs to find the discharge coefficient(cd) using other discharges of the water passing over the crump weir. Three physical models of the crump-type weir were used with different inclinations and a fixed height. Experiments proved that the best discharge coefficient obtained is 1.255 at a distance equal to four times the height of the weir The best section of the crump weir, which is symmetrical upstream and downstream of the weir, is with a slope respectively: 1: 2 and 1: 5; as well as 1: 2 and 1: 2. he researcher [30] used four models of Crump type with Slope 2: 5, 2: 2, 2: 3 to find the discharge coefficient and the submersion coefficient. Draw curves for each weir to find the discharge and error rate to know the characteristics of the weir at different discharges.

VI. CONCLUSION

1. the values of discharge coefficient Cd will increase with an increase in discharge and decrease with a decrease in the dam's height. Also, the increase in the surface roughness leads to an apparent reduction in the discharge coefficient's magnitude Cd.
2. The benefits of the upstream strategy Due to a decrease in flow velocity and an increase in flow depth with lowering p', the fraud number Fr fell. The weir's ability to dissipate flow energy lessens. Models 3 and 4 demonstrate

this, and as a result, there is reduced energy loss. Similar energy dissipation was seen in case 2 with P'/P=0.875 as in case 1 without opening P'/P=1.

3. Increases by increasing the number of openings from one to two and three. The best flow behavior is when using a weir model that contains two holes, compared to the case of models with one hole and three holes. The maximum dissipation in the energy of the flow is in the case of using two holes.
4. Increasing the angle upstream of the weir results in a drop in the discharge coefficient value.
5. The value of Cd is influenced by the crump weir's downstream, crest, and upstream angles. The peak angle rises from 80 to 130, the downstream angle rises from 15 to 40, and the upstream angle drops from 85 to 10 as the Cd lowers.

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