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Hydraulic characteristics of flow over weirs with circular openings

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Abstract Weirs may be used to control the discharge, decrease the water slope in canals and to distribute water between canals for irrigation, etc. The objective of this research was to investigate the influence of using one opening or more in weirs on discharge coefficient (C_d), the hydraulic jump characteristics and velocity distribution downstream of these structures.

This study is based on an experimental program. Three cases of openings arrangements were included, one, two and three openings. Different diameters of openings (D) and different heights from the bed (Z) were tested. The experiments showed that decreasing (D/Z) for weirs which have the same openings numbers and diameters decreases the discharge coefficient (C_d) and the ratio between the length of the submerged hydraulic jump (L_j) and the water tail depth (y_t). Also, decreasing (D/Z) leads to make the maximum velocity near the bed tends to be lifted upward. Moreover, Comparing weirs with different openings numbers but have the same openings area leads to that, weirs with one opening have a bigger (C_d) than weirs with two or three openings but the maximum velocity near the bed of the weir with three openings is less than that with one opening. Also, the hydraulic jump length downstream weir with three openings is less than that downstream weir with one opening.

Finally, equations were developed to deduce the value of the coefficient of discharge for the composite structure.

1. Introduction

Weirs are common engineering structures in irrigation systems in Egypt. They may be used to control the discharge, decrease the water slope in canals and to distribute water between canals for irrigation, etc. Large quantities of water are needed every day to fulfill the continuously increasing requirements of mankind and the various projects such as, land reclamation as well as many industrial projects, Valipour [1,2]. Thus, the capacity of the existing weirs built on those canals became insufficient to pass this increased high water demands.

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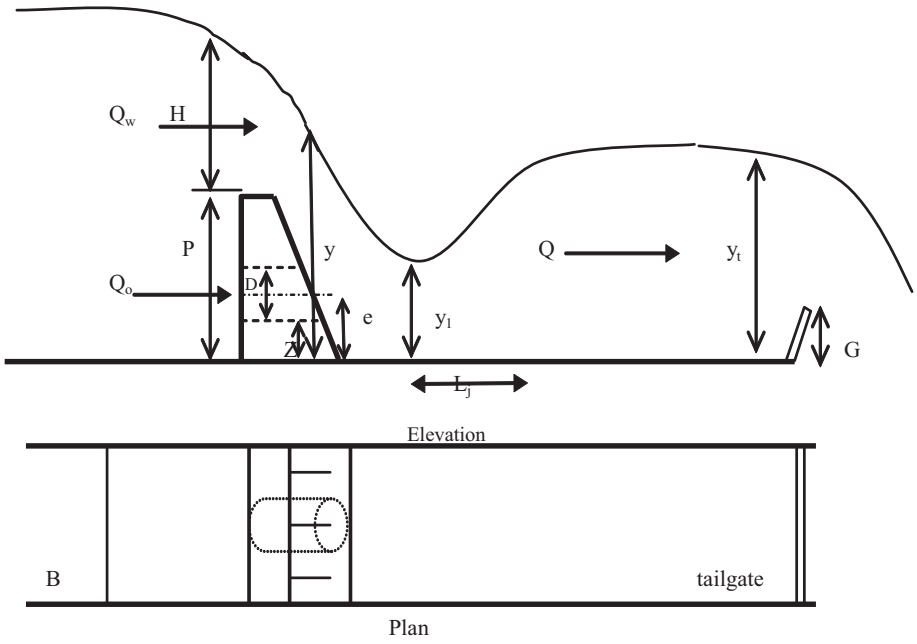

Figure 1 Sketch of the experimental setup.

Therefore, the solution is to replace the old structures by new ones or to modify the existing ones. The modifications may be fulfilled by widening or lowering weir crest, or by adding an opening such as an orifice in the weir body which is the case of Fayoum district weirs.

Great effort has been devoted to study the discharge characteristics over different types of weirs such as Göğüş et al. [3], Hager and Schwalt [4], Sargison and Percy [5], and Valipour [6,7]. The characteristics of the combined flow over weirs and below gates were studied by many researchers using different geometrical combination and different flow conditions. Among them are Alhamid [8], Ferro [9], Ansar [10], Negm [11,12], Negm et al. [13], Samani [14].

Dehghani et al. [15] investigated the dimensions of scour hole downstream of combined free flow over weir and below gate experimentally.

Also, Sobeih et al. [16] investigated the dimensions of scour hole downstream of the weir with openings.

Wolters et al. [17] made various experiments to calculate the discharge for a system consisted of a specific weir and a pipe. They suggested rating curves for all weirs they studied. AbdelHalim et al. [18] calibrated experimentally the flow over existing Fayoum weirs with orifices. A mean value for the coefficient of discharge for the combined structure was found to be 0.623 which was very close to the theoretical values.

Elazizy [19] studied the hydraulic characteristics of a weir combined with a slot. The weir was used with one slot built in the middle third of the weir body with two different slot diameters. A general experimental equation relating the total discharge with the relative head over the weir and the relative circular slot diameter was developed.

Hassan et al. [20] carried out an experimental study to investigate the flow over clear over fall weir with one bottom circular opening. They tested weir models with different heights and different opening diameters. Multiple regression equations based on energy principal and dimensional analysis theory were developed for computing the discharge over clear over fall weir with a bottom opening.

Al-Suhili et al. [21] developed Artificial Neural Networks (ANN) models to express the discharge coefficient for a weir with three rectangular bottom openings as a function of different geometrical and flow variables. They used different openings dimensions and all the openings height measured from the bed. They concluded that the width of opening has the major effect on C_d than the opening height.

Some researchers tested one opening with different diameters. Few researchers tested more than one opening but with fixed diameters. The main objective of this research was to investigate weirs with different openings numbers, diameters and locations to conclude the best decision for increasing the discharge D.S. the weir (using one opening (which maybe already exist and may be only widened) or two or three openings is a better choice, also, the best openings locations). Also, it investigates the influence of using weir with more than one

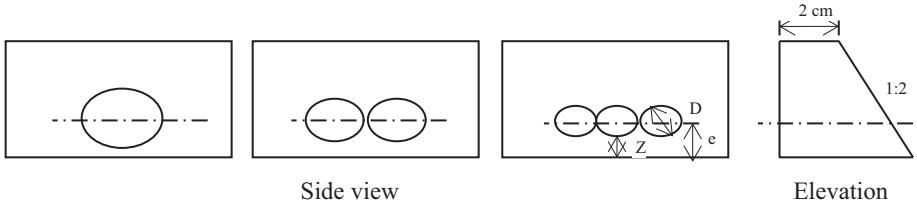

Figure 2 Shapes of the tested models.

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