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# Experimental Study of Discharge Coefficient Proportional Weirs on Lateral Intake

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## 1. Introduction

Lateral intake refers to structures in which the intake operation is performed using a lateral weir overflow. Accurate measurement of flow discharge in open channel and water and sewage transmission networks is of special importance. So far, various types of structures, such as weirs, flumes, and sliding valves have been proposed for measuring flow discharge. Weirs are simple, multipurpose and efficient hydraulic structures used to measure flow rates and water level control in waterways. Among the different types of these structures, proportional weirs that have a special relationship between flow and head of water are well-known due to their application in various engineering fields such as irrigation and drainage, environment, hydraulics and chemistry. Proportional spillway design is based on the desired relationship between discharge and hydraulic head. Based on the relationship between discharge and hydraulic head, proportional weirs are classified into three types, namely linear proportional, quadratic or quadratic and logarithmic proportional weirs. Different types of proportional weirs have been studied by different researchers in order to develop equations by numerical and experimental methods. These studies have been performed to evaluate the geometric shape of the proportional weirs to the lowest sensitivity to the upstream water depth and the lowest error in the calculation of the discharge. The proportional weirs are a group of sharp edge weirs that are highly accurate due to low sensitivity to upstream depth variations. Linear proportional weirs are those that the relationship between their discharge and head is linear.

In this study, based on theoretical fundamentals of proportional weirs, three proportional linear weirs with linear, triangular and reverse triangular, and two reverse triangles and three series of rectangular weirs were designed and tested in rectangular flume equipped with a side channel in hydraulic lab.

## 2. Material and Methods

To reach the objectives of this study, which included the laboratory study of proportional weirs in the lateral intake and the determination of effective parameters on the discharge coefficient, a laboratory set was designed and then several experiments on models designed weirs were performed. In order to organize the experiments in terms of their number and variety, first, the factors involved in determining the discharge coefficient were identified using dimensional analysis and then dimensionless equations were determined and experiments were planned.

According to Buckingham Π theory, given the existence of eight variables and three dimensions, five dimensionless factors were determined and following equation was obtained to estimate the discharge coefficient:

$$C_d = f\left(\frac{L}{P}.\frac{H}{P}.\frac{B}{P}.R_n.W_n.F_r\right)$$

In this equation, *Rn* represents the Reynolds number, *Wn* the Weber number, and *F*r the Froude number. Since the channel width is a fixed value and not a design parameter, the dimensionless variable B/P is less important than the L/P dimensionless variable. It should be noted that L or in other words the length of the weir is one of the design parameters of the weirs. As a result, the variables H/(H+P) and L/(L+P) were determined as dimensionless variables affecting the discharge coefficient, and the experiments were planned to determine the laboratory discharge coefficients against changes in each of these parameters. Figure 1 shows a schematic view of the laboratory arrangement and Figure 2 shows the sections of the proportional weirs under study.

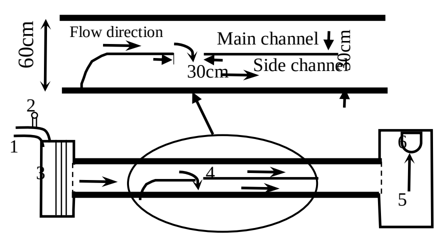


Figure 1. Schematic view of a laboratory flume

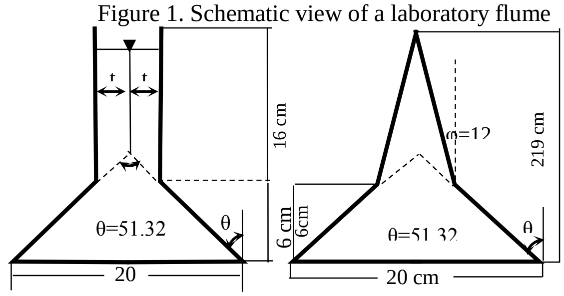


**Figure 2. Sections of some of the proportional studied weirs**

## 3. Results and Discussion

In order to investigate the possibility of a linear relationship between discharge and water head in linear proportional weirs for all experiments, laboratory discharge was plotted against the measured water heads. In Figure 3, a diagram of three weirs is given as an example. Figure 3 shows that there

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is an expected linear relationship between discharge and water head in linear proportional s for all values of p (weir height). Figure 4 shows variations of discharge coefficient against changes in the water depth on the upstream side. Figure 4 also shows that when the passed flow was low in all weirs with increasing of crest elevation relative to the channel bottom, the discharge coefficient decreases, but with increasing discharge flow, the changes of discharge coefficient caused by the increasing the height of weir, decreases.

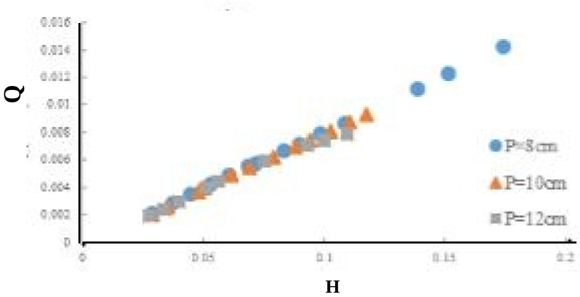


**Figure 3. The relationship between discharge and head in inverted triangular weirs**

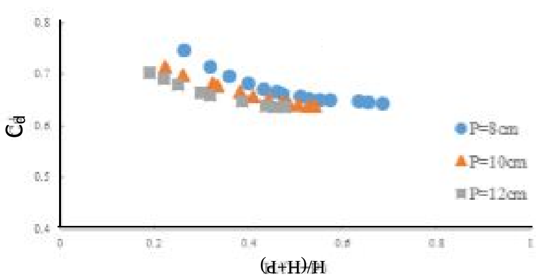


**Figure 4. Variation of laboratory discharge coefficient relative to H/(H+P)**

Based on this, it can be expected that in all types of proportional weirs, due to the geometry of the weir section on the crest, the changes in the flow rate due to changes in water depth in the main channel are significantly less than conventional weirs.

The hydraulic sensitivity of the tested overflows shows their performance well. Figure 5 shows the results of the calculations.

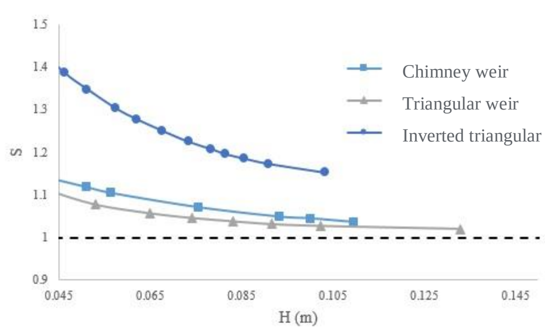


**Figure 5. Hydraulic sensitivity to water head**

As Figure 9 shows, since the hydraulic sensitivity in a linear proportional weirs is equal to one, the hydraulic sensitivity of inverted triangular weirs and chimney weirs is approximately approaching to one, which confirms the basic assumption of a linear proportional weir design.

## 4. Conclusion

The results show that theoretical sensitivity in linear proportional weirs is equal to one. The more the values of the sensitivity of the studied weir are close to the theoretical values, the better the weir will be. In order to estimate the laboratory sensitivity of the above weirs, the derived relationship between the discharge and head of each weirs was used. The results showed that among linear proportional weirs, inverse triangular weir with a linear relationship has better and more accurate hydraulic performance.