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# Study of Hydraulic Characteristics of Gabion Weir

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**Abstract—***A conventional weir generally consists of a body which is impermeable and constructed by concrete or metal body. The primary function of a weir is to raise the level of water and regulate the flow efficiently. For the understanding of gabion weir we may consider it as a cage, box or cylinder filled with stones, rocks, concrete, or sometimes sand and soil for use in civil engineering and other purposes. However the advantage of gabion weir over conventional weir is that it doesn't avoids the longitudinal movement of aquatic life and transportation of physical and chemical material in water. Also it helps in providing the alternative design option that can be adopted for flash flood mitigation. In this paper, we are going to compare the effect on discharge and coefficient of discharge by varying the mean size of gabion material. Four different mean sizes of gabion materials are used in the laboratory experiments and the results are analyzed.*

**Keywords***: Gabion weir; Coefficient of discharge; Gabion material*

## 1. INTRODUCTION

The gabion weir is considered to be more environmental friendly and it has lesser negative impact on the environment. The water which flows through the pores of gabion weir gets purified by the biological action of bacteria present at the surface of gabion materials, which helps in decomposition of the organic matter. Another advantage of gabion weir is the low cost and simplicity in construction. Types of gabion weirs are discussed below:

### 1.1 Vertical gabion weir

The vertical weir is certainly the simplest type, and is often used for small weirs in a system controlling a reach of a stream. In the vertical gabion weir, the nappe is not only aerated, but separated from the downstream face. Since this means that the weir mesh is protected against abrasion and impact by heavy bed material carried in spate conditions, it is a type recommended for training works on mountain torrents.

### 1.2 Stepped gabion weir

The main difference between vertical gabion weir and stepped weir is that the water flowing over the weir dissipates energy at each step.

### 1.3 Sloped gabion weir

When the height of weir is large ranging from 10-15 m, then there is requirement of greater stability which can be achieved by sloping downstream face. The downstream face should be designed in such a way that the nappe adheres to the sloped face of the weir.

Gabion weir has been topic of interest for many researchers. Chinnarasri et al. (2008), studied about the gabion stepped weir, he showed that the ratio of loss of energy in gabion stepped weir is greater than those of horizontal stepped weir. The shape and size of filling material has less effect in energy dissipation. Mohammed (2010) studied about the properties of gabion weir and compared them with the properties of broad crested weir. He also formulated discharge as a function of parameters such as Gabion material diameter, porosity, water level at upstream and downstream end. Pagliara et al. (2013) studied about the rock grade control structures and stepped gabion weir and analysed the scour process and the flow patterns. He compared between the rock grade control structures and stepped gabion weirs in terms of maximum scour depth and it shows that for the same hydraulic conditions, differences can be seen in form of non dimensional scour depths.

In this paper we are going to study about coefficient of discharge and how it gets affected with change in the mean size of gabion material and porosity. For that four models of gabion weir were prepared with different mean sizes of gabion material and then their discharge behaviour is studied..

## 2. LABORATORY EXPERIMENTS

The experiments were carried out in tilting bed flume with dimensions as length =15 m, width = 0.4 m and height = 0.5 m. Figure1. shows the tilting bed flume on which the experiments were performed. A model of gabion weir was made with help of iron bars and fabricated with wire mesh with opening of 1.5 cm and it was kept at a distance of 7 m from the inlet of the flume. Four different size of gabion materials were used one by one of mean diameter ($D_{50}$) of 4.08 cm, 2.54 cm, 2.165 cm, 1.565 cm. Discharge through the weir was calculated and after that $C_d$ was calculated. Here the dimensions of the weir used are width of the weir crest (L) = 38.5 cm, Length of weir (B) = 40.5 cm and height of weir (P) = 24.5 cm. Figure 2. shows the Gabion weir used in the flume for experiments. The discharge was calculated using a sharp crested weir at the end of the flume using Rehbock's formula given as:

$$Q = \frac{2}{3} C_d \sqrt{2g}\, L\, H^{1.5} \qquad \text{equation (1)}$$

$$C_d = (0.605 + 0.08\frac{H}{Z} + \frac{0.001}{H}) \qquad \text{equation (2)}$$

Where L = length of sharp crested weir = 0.59 m
Z = Height of sharp crested weir =0.28 m
H = Head over sharp crested weir

The discharge calculated by the Rehbock's formula is then used to find out the $C_d$ of the gabion weir using the dimensions of the gabion weir as input values for equation (1). Also the porosity of the weir is find out by using the volume of the gabion material. We know that the porosity is the ratio of volume of voids to the total volume. For volume of voids we calculate volume of stones by Archimedes principle. Volume of stones is then subtracted from total volume of weir (24.5cm × 38.5cm × 40.5cm) to get volume of voids. This procedure is repeated for four times to find porosities for each model.

## 3. RESULTS AND DISCUSSION

The following table 1. gives us the information about the 40 different runs of the flume. There are 10 readings for each size of gabion material**.** Figure2. shows the flow over gabion weir. It is observed that the water flows through the pores of gabion weir as well as over the body of weir. It is seen that when the filling material inside the weir is of bigger size then the head over the weir is smaller and vice versa.

**Figure 1. Tilting bed flume used in the experiment**

**Figure2. Gabion weir used in the experiment**

From the table 1. given below we can see that the discharge and coefficient of discharge of the gabion weir has been calculated using the equation (1) and (2).

**Table 1: Readings of gabion weir**

| **H in cms** | **Avg head in cms** | **Porosity** | **$D_{50}$ in cms** | **Q in lit/sec** | **Average Q in lit/sec** | **$C_d$** | ***Avg $C_d$*** |
|---|---|---|---|---|---|---|---|
| 5.7 | 7.26 | 52.5 | 4.08 | 11.717 | 17.604 | 0.757 | *0.7828* |
| 6.3 | | 52.5 | 4.08 | 13.584 | | 0.756 | |
| 6.5 | | 52.5 | 4.08 | 14.357 | | 0.762 | |
| 6.8 | | 52.5 | 4.08 | 16.336 | | 0.81 | |
| 7.3 | | 52.5 | 4.08 | 17.57 | | 0.78 | |
| 7.5 | | 52.5 | 4.08 | 18.022 | | 0.772 | |
| 7.9 | | 52.5 | 4.08 | 19.309 | | 0.765 | |
| 8 | | 52.5 | 4.08 | 20.53 | | 0.8 | |
| 8.2 | | 52.5 | 4.08 | 21.523 | | 0.806 | |
| 8.4 | | 52.5 | 4.08 | 23.1 | | 0.82 | |
| 6 | 7.82 | 40.7 | 2.54 | 12.825 | 20.1107 | 0.76 | *0.7941* |
| 6.2 | | 40.7 | 2.54 | 13.584 | | 0.77 | |
| 6.8 | | 40.7 | 2.54 | 15.146 | | 0.75 | |
| 7.2 | | 40.7 | 2.54 | 16.357 | | 0.745 | |
| 7.5 | | 40.7 | 2.54 | 19.745 | | 0.846 | |
| 8 | | 40.7 | 2.54 | 21.97 | | 0.85 | |
| 8.6 | | 40.7 | 2.54 | 23.32 | | 0.81 | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 9 | | 40.7 | 2.54 | 24.76 | | 0.8 | |
| 9.3 | | 40.7 | 2.54 | 26.2 | | 0.81 | |
| 9.6 | | 40.7 | 2.54 | 27.2 | | 0.8 | |
| 6.3 | 7.98 | 24.9 | 2.165 | 15.526 | 20.7616 | 0.86 | *0.8092* |
| 6.7 | | 24.9 | 2.165 | 16.768 | | 0.85 | |
| 7 | | 24.9 | 2.165 | 17.576 | | 0.835 | |
| 7.2 | | 24.9 | 2.165 | 18.49 | | 0.842 | |
| 7.6 | | 24.9 | 2.165 | 19.74 | | 0.829 | |
| 8.2 | | 24.9 | 2.165 | 20.61 | | 0.772 | |
| 8.7 | | 24.9 | 2.165 | 21.52 | | 0.738 | |
| 9 | | 24.9 | 2.165 | 24.52 | | 0.791 | |
| 9.4 | | 24.9 | 2.165 | 25.72 | | 0.785 | |
| 9.7 | | 24.9 | 2.165 | 27.146 | | 0.79 | |
| 6.4 | 8.18 | 20.97 | 1.565 | 15.526 | 21.322 | 0.86 | *0.8093* |
| 6.8 | | 20.97 | 1.565 | 15.93 | | 0.79 | |
| 7 | | 20.97 | 1.565 | 17.576 | | 0.835 | |
| 7.2 | | 20.97 | 1.565 | 17.997 | | 0.82 | |
| 7.6 | | 20.97 | 1.565 | 19.277 | | 0.809 | |
| 8 | | 20.97 | 1.565 | 21.074 | | 0.819 | |
| 8.4 | | 20.97 | 1.565 | 22.9 | | 0.82 | |
| 9 | | 20.97 | 1.565 | 24.29 | | 0.79 | |
| 9.6 | | 20.97 | 1.565 | 26.2 | | 0.81 | |
| 10 | | 20.97 | 1.565 | 26.66 | | 0.74 | |

## 4. CONCLUSION

From the experimental study and results we can infer that

- The model with larger size of mean diameter of gabion material has lesser discharge also the porosity is high in this case.
- The head over the gabion weir is less where the mean diameter of gabion material is higher, whereas the mean diameter with lesser size gives higher discharge and the porosity is less in this case.
- The head over the gabion weir is higher where the mean diameter is lesser.

**Notation**

$D_{50}$ = Mean size of gabion filling material

$C_d$ = Coefficient of discharge

L = Width of weir crest

B = Length of weir

P = Height of weir

Z = Height of sharp crested weir

H = Head over the weir

Q = Discharge

G= Acceleration due to gravity

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