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EXTENDED ABSTRACT

Estimation of the Drag Coefficient of Gabion Groin with Different Porosities Using a Measurement of Experimental Flow Field and Solution of Navier- Stokes Equations

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1. Introduction

Rivers affected by natural factors or human interventions are involved in Corrosion of bed and sides. One of the common methods in controlling and protecting riversides is the use of groin. Gabion groynes are a kind of spur dike. On the basis of hydrodynamic the contrast between gabion groin of river and the environmental fluid are complex and computing of the affected force on them are so important. If a real fluid, with a constant velocity, passes around a groine, there is a drag force due to fluid viscosity. Lee et al (2011) used the time average of Navier-Stokes equations and k-ε turbulent model to predict the flow around permeable pile groins to develop a 2-D numerical model. Their results indicated that the direction of the approaching flow is diverted by increasing the flow rate, which is an advantage to protect the river banks Duan and Nanda (2006) simulated the distribution of suspended sediment concentrations around a spur dike using a two-dimensional depth averaged hydrodynamic model and solution of two-dimensional Navier-Stokes equations. Azinfar and Kells (2009) studied the flow around a single spure dike with different sizes using measurement flow and depth and using momentum equation. They resultes that an increase in the blockage due to the spur dike plate is the main parameter responsible for an increase in the spur dike drag coefficient, hence the associated flow resistance. The effect of porosity percentage of these porous groines in channels and rivers is not carefully investigated on how the pressure and drag force on these groin is distributed. Therefore, the necessity of studies in this field is observed.

2. Methodology

The experiment is conducted at the Hydraulic Laboratory of Bu-Ali Sina University. The laboratory channel consists of a concrete flume with a length of 15 meters, a height and width of 0.6 meters. The walls and the floor of the channel are made of transparent glass with a thickness of 10 mm. Impermeable groin is made of Plexiglas and porous groines with a porosity percentage of 20, 40 and 60% are gabion. The height, length and width of the groin are 60, 10 and 2cm, respectively. In this research, the discharge of flow, the mean velocity of approaching of flow, the flow depth, the froud number and the reynolds number were 0.025 $(\frac{m^3}{s})$, 0.33$(\frac{m}{s})$, 12.5(cm), 0.3 and 29000, respectively. ADV was used to measure three- dimensional velocities and the components of Reynolds stresses. This research Combined Experimental method and numerical solution, so the grid in this research is 3D nonuniform backward staggered grid. In this research, after obtaining the velocity field around the groin, regarding the Reynolds stresses, the time averaged

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Navier- Stokes equations (Reynolds equations) are solved for the turbulent flow using FVM method. The main step in the finite volume method is to discretize and integrate the governing equations on a control volume to achieve a discrete equation at the P node point. The mean time equation for the φ scalar is as follows:

$$\frac{\partial(\phi)}{\partial t} + div(\phi u) = div\left(\Gamma_{\phi}^{*} grad\phi\right) + \left[-\frac{\partial\overline{\acute{u}\varphi}}{\partial x} - \frac{\partial\overline{\acute{v}\varphi}}{\partial y} - \frac{\partial\overline{\acute{w}\varphi}}{\partial z}\right] + S_{\phi} \qquad (1)$$

In order to solve the discretized equations, the upwind differencing scheme, the hybrid differencing scheme, power law scheme and Quick scheme (modified by hayas) has been used. Then, using the relation between velocity and pressure, a computational code was prepared for calculating the pressure field based on the experimental velocity field. So the Drag force affected on groin and Drag coefficient would be determined.

3. Results and discussion

3.1. The Drag Force on the Side and Middle Obstacles of the Channel with Different Porosities

In Fig. 1, the bar graph of the drag force applied to the gabion groines with different porosity percentage is drawn using the power law scheme. According to the diagrams, the drag force applied to the gabion groines decreases by increasing porosity from 0 to 60 percent. In gabion groines, with increasing porosity, due to the flow of water through the groin, a lower pressure is formed at the upstream and a lower pressure gradient occurs between the upstream and downstream. As a result, less flow separation and back flow are created, and fewer turbulence occur in the flow pattern.

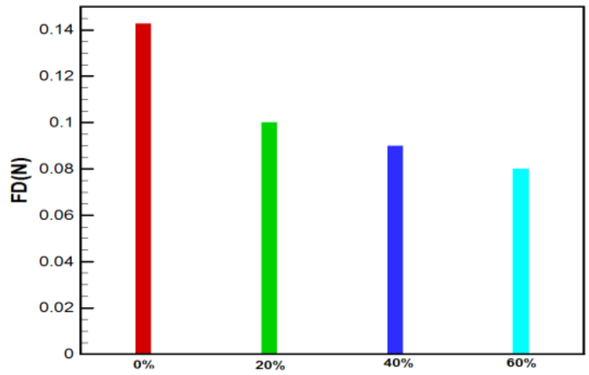

Fig. 1. Bar graph of the drag force applied to the gabion groines with different porosity percentage

3.2. Drag Coefficient of Side and Middle Obstacles of the channel with Different Porosity

In Fig. 2, the bar graph of the drag coefficient of gabion groines with different porosity percentage is drawn using the power law scheme. With increasing porosity, due to the adverse pressure gradient and lower pressure gradient, the flow mix rate is reduced and consequently the drag coefficient decreases as well.

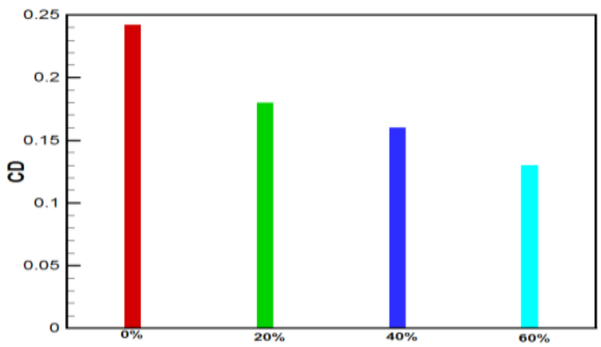

Fig. 2. The bar graph of the drag coefficient of gabion groines with different porosity percentage

3.3. Relationship between drag coefficient and obstacle porosity percentage

According to the results, changes in the drag coefficient in terms of porosity percentage are plotted for side obstacles in Fig. 3. As it can be seen in this figure, the relation between the drag coefficient and the porosity percentage follows the third degree curve relationship by a good approximation.

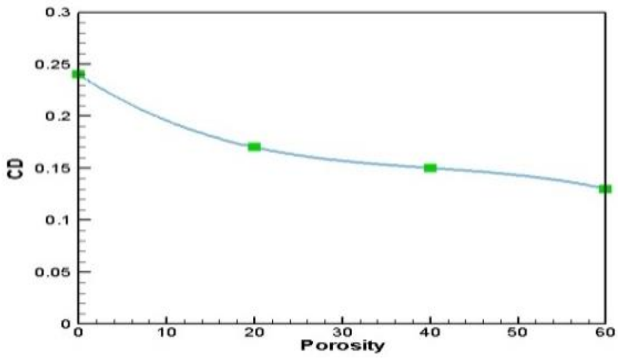

Fig. 3. Variation of drag coefficient with porosity percentage for side obstacles using power law scheme

4. Conclusions

The results show that, the drag force applied to the gabion groins and drag coefficient of gabion groines decreases by increasing porosity percentage. Additionally, if the drag coefficient is calculated, the relationship between this coefficient and the porosity percentage of the side obstacles is the third degree curve.

5. References

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