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EXTENDED ABSTRACT

Effect of Intake Particle Dimension and Grain Size on Discharge Coefficient in Porous Bottom Intakes Using Physical Modeling

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Introduction

Water intake from the river is done using several methods. Each method has its own features and limitations. In steep mountain rivers with irregular bed, high values of sediment transport and flash floods may prevent the application of gated dams; therefore, the bottom intakes are often used. In this method, in some part of the river width and length, a trench is created with a proper cross section and water is flowed through this trench into the diversion channel. In order to prevent the coarse particles to enter, top of the trench is covered with bottom rack bars. Corrosion of the bars, clogging, and maintenance are the common problems of bottom racks, which make them unusable in long term. To solve these problems, a new system of bottom intake with porous media is introduced. In this method, after trenching in the river bed, materials with appropriate aggregation are dumped in the trench and water intakes from the river through a diversion channel. This means that a portion of flow into the porous media; then move to the diversion channel. Another portion of the water passes over the bottom intake and finally drive to the river. Usage of the porous media has, however, many limitations; but it has some advantages, such as, no suspended solids in the water, respect for the environmental problems, no change in natural morphology of the river, withstanding in different weather conditions, and dealing with the problem of freezing, and corrosion, easy to construct and applicability, affordability and availability of materials. Despite a long history of research in thre field of bottom rack intakes, few studies about these structures with porous media have been previously done. In previous experiments, in order to separate the diverted flow from the non-passed flow, a bottom intake with porous media with a diversion channel parallel to the main channel was used, so that the diverted flow was unidirectional to the main channel. But, in practice, diversion channel in the bottom intakes is usually performed perpendicular to the main channel. Therefore, it affects the hydraulic parameters and diverted discharge. Besides, in previous experiments, by considering the constant height and length, the effect of these two factors has not been investigated for the intake. Therefore, in the present study, in order to precisely investigate the hydraulic behavior of the bottom rack intakes, in addition to the implementation of a channel perpendicular to the main channel as a diversion channel, various factors such as the length and height of the intake, the effects of uniformity of particles and different slopes of intake have been experimentally investigated. The results of experiments on laboratory models in this study may reveal some of the unknown points in application of this method and it provides the possibility of design and operation of this structure in the natural environment.

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Methodology

In order to model a bottom intake with porous medium and to conduct experiments, a main flume with the walls of the glass materials in the dimensions of the 10* 0.30* 0.50 cube meter and a diverted flume by the dimensions of the 1* 0.45* 0.50 cube meter was used. To prepare an intake in the distance of 5 m at the beginning of main flume, the space has been considered so that the possibility of conduction is with three length and height (L_1=15 cm, L_2=30 cm, L_3=45 cm) (H_1=10 cm, H_2=15 cm, H_3=20 cm). The inner surrounding of intake was filled with four different types of gravel with the average diameters of P_1=9.72mm, P_2=13.41mm, P_3=15.30 mm, P_4=17.75mm. In every experiment by passing different discharges over the intake, the rate of the diverted discharge was measured . Rectangular weir was selected at the end and beginning of the main flume to measure the flowrate .

Results and Discussion

The results showed that inflow discharge increases the rate of diverted discharge but the proportion of diverted discharge to inflow discharge is decreasing. Grain size of the porous media has a great influence on the diverted flow. By increasing the grain size, the void spaces of granular material increases, and consequently, the diverted flow increases. Therefore, that grain size P_4 has the highest rate of diverted discharge. The result of void space increasing in this kind of grain size. Researching on diverted discharge with different length and height showed increasing intake length and height from L_1 to L_3, H_1 to H_3 causes increasing in diverted discharge. The results of this study indicated the reduction of diverted discharge at the new conditions. The ratio of diverted discharge to the inflow rate in Kooroshvahid, et al (2011)' experiments was in the range of 35 to 60 percent; while this ratio is decreased and it is in the range of 24 to 50 percent.

Conclusions

In mountain rivers, bottom rack intakes are suitable method, but given the limitations these types of intakes, the application of the bottom intakes with porous media can be a viable alternative for bottom rack intakes. Therefore, in this study, an experimental study of flow conductivity in bottom intake with porous media was performed. For this purpose, by taking into account the length, height and aggregates with different grain size distributions for porous media, the characteristics of these intakes were investigated. Finally, by using dimensional analysis, experimental data and multivariate regression, a new equation to estimated diverted discharge coefficient with coefficient of determination R^2=0.854, was suggested. The theoretical predictions in comparison with the experimental results have shown good consistency.

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