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Simulation of Sedimentation Pattern in Upstream of Duckbill Weirs Using Submerged Vanes

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1. Introduction

Duckbill weir is one of the water level control structures in irrigation networks. The study of these structures is very important due to the extensive use of duckbill weirs in irrigation networks. If Sediments are transferred into the irrigation networks, they are trapped in the upstreaming of weir and can affect the upstream water level.

The bottom gate is usually used in duckbill weir for transferring the sediment to downstream. The opening of the gate affects the sedimentation pattern locally. Therefore, in this study the submerged vanes are used as the sediment control of duckbill weir. Submerged vanes are small hydraulic structures that are installed on the riverbed to modify the near-bed flow pattern and to control the sediments movement. Submerged vanes are used in different arrangements. The commonly purpose of the vane installation was the control of sediment entry to the water intake.

The Fow-3D software is one of the CFD softwares for simulation of the flow and the sedimentation pattern. It employs specially developed numerical techniques to solve the equations of motion for fluids to three-dimensional solutions to flow problems. The Flow-3D software solve mass continuity and momentum as well as the sediment transport equations for flow and sediment simulation.

There are no studies regarding the use of submerged vanes for controlling the sediment in upstreaming the duckbill weir. In the present study, sedimentation pattern was studied experimentally and numerically when the gates are installed in both front and side walls of the weir and submerged vanes used in upstream of weir.

2. Method

In this study, submerged vanes are used for flushing the sediment to the downstream in addition to the frontal and lateral gates. The experiments were conducted in a rectangular flume with 12 m length and 0.6 m width. The vanes were located in four rows which were perpendicular to the side wall direction. The flow and sedimentation pattern along with the discharge coefficient of duckbill weir have been computed when the gates are installed in both front and side wall of the weir and submerged vanes were used in upstream weir. The Flow-3D software has been also used for simulation of flow and the sedimentation pattern.

3. Results

The results showed that the submerged vanes create secondary flow which is so effective for flushing the sediment especially in value of $\frac{H}{p} \geq 0.33$ (H is the head over the side wall and p is the weir height). The use of submerged vanes with the same height as weir not only increases the sediment transport to downstream but also increases the discharge coefficient. The comparison of numerical and laboratory data shows that the Flow-3D software can simulate discharge coefficient and sedimentation pattern with high accuracy.

4. Conclusion

To prevent the sediment accumulation in upstreaming of duckbill weir one can use the side gates and submerged vanes together for a values of H/P= 0.1-0.5. The results of image processing showed that there are good agreement between numerical and experimental sediment pattern. The maximum relatived error for simulation of sediment pattern is 14.4 percent.

Figure 1 shows sedimentation pattern in the upstream duckbill weir for h_v=0.13 m (h_v is height vanes). As seen in this figure, by increasing the ratio of H/P, the efficiency of sediment flushing increases.

Table 1 shows the maximum error of simulation sedimentation pattern by using image processing method. The maximum error of simulation is 14.4 % for the ratio of H/P=0.2.

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(a)

(b)

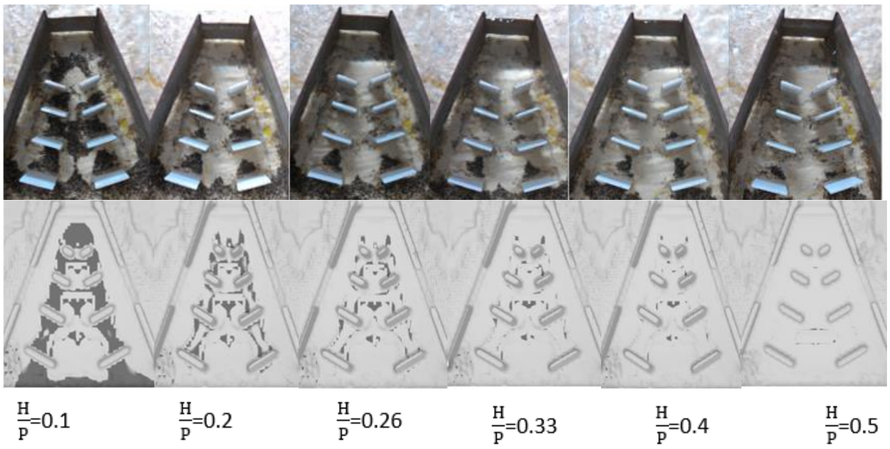

Fig. 1. Sedimentation pattern in the upstream duckbill weir (hv=0.13 m): a; experimental sedimentation pattern, b; simulated sedimentation pattern

Table 1. Maximum error of simulation sedimentation pattern

H/P	0.1	0.2	0.26	0.33	0.4	0.5
Maximum error (%)	9.5	14.4	12	12.5	10.7	5.8