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Experimental Study on the Effects of Suction Mouth Deformation on Sediment Discharge Efficiency of Dams Reservoirs using Hydrosuction Systems

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Extended Abstract

Introduction

Dam reservoir sedimentation is known as one of the main serious problems that mainly affects the efficiency of dam's operation. Sedimentation may also block the conduits and it can destroy turbines, sluices, and valves. So it is necessary to find a way to solve this problem. In this regard, hydrosuction considered as a proper alternative and a potentially efficient method to remove the superficial deposited sediments from reservoirs. Hydrosuction system consists of a large pipeline working with an inlet suction tube lying on deposited sediments in the reservoir. In hydrosuction systems, the deposited sediments are withdrawn, as a mixture of sediments and water, from the reservoir and directed to downstream. The major advantage of using hydrosuction method is its economic aspects since the system doesn't need extra energy for operation. Environment friendly method, hydrosuction can be used all over the reservoir, where the output and the volume of sediment removal could be under control. Researchers have tried to evaluate and improve the efficiency of this system. In this study, the effects of different shapes and forms of the suction mouth (tube inlet) on the efficiency of hydrosuction system in sediment removal were investigated. To achieve this goal, several experiments were carried out using different shapes of the suction mouth including the plain-type (circular) and wedge-shaped in the middle of the suction mouth.

Methodology

In the current work, the hydrosuction effective parameters were considered as the follow: water density (ρ), dynamic viscosity (μ), gravity acceleration (g), hydrosuction pipe diameter (D_p), diameter of sediment particles (D_{50}), hydrosuction pipe velocity (V), length of pipeline (L_p), sediment density (ρ_s), the distance between inlet pipe and surface of sediment layer (H_p), the height of water on the sediments (H_w), the deference of height between water level and hydrosuction output (H), the angle between the head of the suction inlet and pipe (α), the shape of suction inlet (β), coefficient of particle shape (λ), sediment discharge (Q_s), scour hole depth

(L), scour hole diameter (R), scour hole volume (Λ), and time (t). Extracted dimensionless parameters by using Buckingham theorem are as follow:

$$f(Q/VD_p^2, \rho_s/\rho, \rho VDp/\mu, D_{50}/D_p, L_p/D_p, H/D_p, Q/VD_p^2, H_p/D_p, H_w/D_p, \alpha, V^2/D_p g, V_f/D_p, \beta, \lambda, Q_s/VD_p^2, \Lambda/D_p^3)=0 \quad (1)$$

Considering V, t, ρ, ρs, $D50$, Dp, Lp, and H as constants throughout the experiments, just two dimensionless parameters, Hp/Dp and (Λ/Dp^3), were evaluated in this study.

The experiments were conducted in the hydraulic and water engineering laboratory of Water Engineering Department of Shahid Bahonar University, Kerman. The height, width and length of physical model tank (as the reservoir) were 70, 100 and 100 centimeters, respectively, and the diameter and length of hydrosuction pipeline were 3 and 250 cm respectively. Sediments samples were classified as sand with $D50$ = 0.51 mm. Before starting each experiment, the bottom of the model filled with a layer, 15 cm, of sediments . In this study, the effect of the suction mouth formation, as well as the effect of distance between the inlet pipe and the surface of sediments on the performance of hydrosuction system, were evaluated. The suction mouth formation included the plain-type (circular) and wedge-shaped in the middle of the suction mouth. The wedge-shaped type was considered with four angles of the pipe opening relative to the tube stretch (α =15, 30, 45, and 60 degrees). The values for Hp were considered in three levels of 2cm above the surface of the sediment, on the sediments surface, and 2cm under the surface of the sediment.

Results and Discussion

The results of the experiments showed that with increasing the ratio of Hp/Dp , (Dp is the pipe diameter), the volume of sediment removal (Λ) decreased. Also, at α =15o and 30o, the ratio of (Λ/Dp^3**)** decreased, comparing to the reference test (plain-type, α = 90°), while at α = 60°, the value of (Λ/Dp^3**)** increased. By assuming a constant value for the ratio of Hp/Dp, the results implied that the ratio of (Λ/Dp^3) and the concentration of the sediment outflow enhanced if the amount of α increased. By assuming a constant ratio value of Hp/Dp, just at α = 60° the ratio of (Λ/Dp^3) increased compared to the reference test. Results revealed that a better performance of the hydrosuction system would occur by using a wedge-shaped suction mouth, α = 60° , and locating the suction tube two cm under the sediment surface.

Conclusion

In this study the hydrosuction process with 4 different angles of the pipe opening relative to the tube stretch (15, 30, 45 and 60), and 3 distances of the pipe inlet from the sediment level (above, tangent, and under the sediment level) were tested. Considering a constant wedge-shaped angle (α), the results indicated that by increasing the distance of the pipe inlet (H_p/D_p) from the sediment level, the amount of the extracted sediment will be decreased (Λ $/D_p^3$). These results are in line with the results of Forutan-Eghlidi *et al* (2019). In general only at α=60 the wedge-shaped pipe have greater efficiency compared to normal pipe shape. In all conducted experiments, the middle wedge-shaped pipe with α=60 and H_p/D_p=-0.66 had the greatest performance in dredging the sediments.

Keywords: Deformation of Inlet Opening, Hydrosuction Sediment Discharge, Sedimentation, Suction Tube