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Experimental and CFD Simulation Studies on the Flow Approaching a Type-A Piano Key Weir

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Many dams around the world are ageing and require upgradation in terms of spillway capacity and other safety aspects. In recent times, challenges faced due to global warming, climate change and cloudburst events have grown not just in numbers but also in extremity. Consequently, several dams and diversion structures are being modified to cope up with the floods resulting from such events. Piano key weir (PKW) has effectively been used in many dam upgradation projects, especially in France and Vietnam, to enhance the discharge capacity of the existing ogee-crested weirs or labyrinth weirs. It has also been used in a diversion scheme in India (Sawra Kuddu). The flow field around a PKW is spatially varied, complex and three-dimensional in nature. The previous researches on PKWs were predominantly focused on the effect of different parameters on its discharging capacity and limited studies are available on the flow field, sediment movement and scouring at PKWs. Considering these gaps, this study was initiated to understand the flow pattern near PKW and its effect on the sediment transport over PKW. Presented here is the experimental work carried out at IIT Roorkee, India on a Type-A PKW flume model with two discharge values, the CFD simulations of those two flow conditions and a comparison between the results. The time-averaged velocity values were measured at different locations in the front of inlet and outlet keys (upto a distance of 0.1 m from the bed level) using a 3D Acoustic Doppler Velocimeter. The simulations were performed in Ansys (academic 19.1) CFX solver using finite volume method, standard k-ε turbulent model, (where k denotes the turbulent kinetic energy and ε is the rate of dissipation of k) and multiphase (volume of fluid) modelling. The experimental results showed an increase in the depth-averaged longitudinal flow velocity towards the inlet, but a decrease in that towards the outlet. A significant rise in the upward velocity (in the outer flow region) towards both the keys was observed experimentally and numerically. Both the approaches also indicated a significant increase in the lateral velocity near the inlet, especially in the inner flow

region. CFD simulations clearly showed decelerating and accelerating flow zones in front of the outlet and inlet keys, respectively, and also revealed an accelerating flow over the inlet. However, the velocity profile inside the inlet key could not be measured experimentally, possibly due to flow unsteadiness, high turbulence and flow separation, and it demands further research. The CFD results generally underestimated the velocity values for the measured 0.1 m depth of flow and the mean absolute error values for the resultant velocity were 18.32% and 15.52% for the two discharges, respectively. The rise in the approaching flow velocity components towards the inlet and the sloping key enhance the opportunity of sediment passage over a PKW in comparison to other weirs. Extending this work, the study on the flow field near two-cycles and three-cycles PKW models is undergoing.