ABSTRACT

Spillways are an important part of the dams, which are constructed separately as an auxiliary structure to release surplus flood water more than the reservoir's storage capacity. This study presents a general introduction to spillways and their classification based on different criteria. Orifice (Breast wall) spillways are most commonly used in run-of-river projects due to their dual functionality, i.e., passing excess flood water and sediment disposal. An integrated hydraulic modelling approach, including experimental and numerical studies, is used to study the flow characteristics of an orifice spillway under gated and ungated flow conditions. The experimental study is carried out on a scaled rectangular flume model in the hydraulics laboratory, Department of Civil Engineering in IIT Roorkee. The experiment model is a glass rectangular flume of dimensions of width 986 mm and of height 1000 mm consists of two bays with two unequal round nosed piers of 100 mm, 200mm dia and provided with an ogee bottom profile, an orifice roof profile and a radial gate. The experimentation is done for three flow conditions, initially under free-flowing in which the water is allowed freely without any control at tail level, secondly in submergence flow condition where water is allowed freely with maintaining the tail water level and finally gated flow conditions, where the flow is allowed for each gate opening with maintaining both upstream level at FRL and tail level at downstream end and the results of water surface levels, and pressures are noted. The flow is observed orifice flow when the flow is allowed through single bay only and free weir flow when flow is allowed through all bays. The stage discharge rating curve at upstream location from the barrage axis is plotted for gated and free flow condition. The numerical study is carried out on flume model using ANSYS Fluent software using Volume of Fluid (VOF) Multiphase model with an Open Channel (two-phase model) Sub model and single phase model and the governing fluid flow equation, Reynolds' Averaged Navier Stokes Equation (RANS) is solved using turbulence models like k-epsilon realisable viscous model with scalable wall functions to simulate two-phase flow and single phase flow. The flume model is developed with actual dimensions in ANSYS Fluent, and using the experimental observations, the free water surface profiles and pressure plots are developed for free flow conditions, and these levels are used to validate the numerical model results. After validating the numerical results, the numerical model is used for further analysis to study the flow characteristics in gated conditions. The free water surface profiles and streamlines from CFD studies are presented in this study and compared with the experimental values. Numerical analysis is performed with a single-phase model and multi-

phase VOF model for all the discharges with the known tail water elevation obtained from experimental model results to determine the upstream levels, the downstream water level for full discharge in two bays at the end sill in free flow and gated condition. It is found that in single-phase model analysis, the effect of submergence is not analysed but in multiphase VOF model analysis, they are found to match. The coefficient of discharge of a submerged ogee weir is calculated for free flow ungated condition in experiment is 1.629 in submerged condition and from the CFD Analysis for free flow ungated condition, Cd is 1.607 in submerged condition and after submergence correction, the corrected coefficient of discharge for a free ogee weir is 2.04 in experiment analysis and 2.03 from CFD analysis. The coefficient of discharge calculated for the orifice in submerged condition is 0.907. The water surface profile from steady analysis of the Multiphase VOF model is found to match the experimental values almost exactly. The cavitation index from the experimental pressure values at the minimum pressure location for maximum discharge is calculated for free flow conditions and found not to be prone to cavitation.

Keywords: Dam Failures, Hydraulic Problems, Hydraulic modelling, Turbulence, Volume of Fluid, Spillways flow dynamics, Rapidly Varied flow, Orifice Spillways, Physical Models, CFD modelling, ANSYS FLUENT, etc.