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Simulation of the Flow in a Circular Vertical Spillway Using a Numerical Model

Authors : Mohammad Zamani, Ramin Mansouri

Abstract : Spillways are one of the most important hydraulic structures of dams that provide the stability of the dam and downstream areas at the time of flood. A circular vertical spillway with various inlet forms is very effective when there is not enough space for the other spillway. Hydraulic flow in a vertical circular spillway is divided into three groups: free, orifice, and under pressure (submerged). In this research, the hydraulic flow characteristics of a Circular Vertical Spillway are investigated with the CFD model. Two-dimensional unsteady RANS equations were solved numerically using Finite Volume Method. The PISO scheme was applied for the velocity-pressure coupling. The mostly used two-equation turbulence models, k-ε and k-ω, were chosen to model Reynolds shear stress term. The power law scheme was used for the discretization of momentum, k, ε, and ω equations. The VOF method (geometrically reconstruction algorithm) was adopted for interface simulation. In this study, three types of computational grids (coarse, intermediate, and fine) were used to discriminate the simulation environment. In order to simulate the flow, the k-ε (Standard, RNG, Realizable) and k-ω (standard and SST) models were used. Also, in order to find the best wall function, two types, standard wall, and non-equilibrium wall function, were investigated. The laminar model did not produce satisfactory flow depth and velocity along the Morning-Glory spillway. The results of the most commonly used two-equation turbulence models (k-ε and k-ω) were identical. Furthermore, the standard wall function produced better results compared to the non-equilibrium wall function. Thus, for other simulations, the standard k-ε with the standard wall function was preferred. The comparison criterion in this study is also the trajectory profile of jet water. The results show that the fine computational grid, the input speed condition for the flow input boundary, and the output pressure for the boundaries that are in contact with the air provide the best possible results. Also, the standard wall function is chosen for the effect of the wall function, and the turbulent model k-ε (Standard) has the most consistent results with experimental results. When the jet gets closer to the end of the basin, the computational results increase with the numerical results of their differences. The mesh with 10602 nodes, turbulent model k-ε standard and the standard wall function, provide the best results for modeling the flow in a vertical circular Spillway. There was a good agreement between numerical and experimental results in the upper and lower nappe profiles. In the study of water level over crest and discharge, in low water levels, the results of numerical modeling are good agreement with the experimental, but with the increasing water level, the difference between the numerical and experimental discharge is more. In the study of the flow coefficient, by decreasing in P/R ratio, the difference between the numerical and experimental result increases.

Keywords : circular vertical, spillway, numerical model, boundary conditions
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