Proper Numerical simulation of water surface profile over stepped spillway Using Different Solvers

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Abstract

Enhancing the energy dissipation along a spillway is of great importance for more efficient design of the downstream structures. In this regard, a number of steps can be added to the spillway in order to increase the flow turbulence. By this action the dimensions of stilling basin and consequently the cost is significantly reduced. In this research the flow over stepped spillway and the downstream of hydraulic jump is modeled using FLUENT and FLOW-3D softwares. The water surface profile over the spillway and the hydraulic jump is then compared with that of the experimental model and good agreement is observed. The capability of FLOW-3D in allowing the air to escape through free surface is investigated by simulating a dam break problem and comparing it with the existing experimental result. The results show that this software allows the air escape through a free surface if the Drift-flux model and gas escape model is invoked.

Key words: Spillway, Hydraulic jump, water surface profile, FLUENT, FLOW-3D

1. Introduction

Spillways are a kind of hydraulic structures that are used to convey the water when the reservoir capacity is less than the difference between the volumes of inflow and outflow. Spillways can be classified into different groups such as Ogee spillway, Chute spillway, Side channel spillway, Shaft spillway, Siphon spillway and stepped spillway.

Stepped spillway has been used over 3000 years ago. In recent years high attention is given to this kind of spillway. In 19 and 20 centuries many of the spillways were constructed as stepped spillway, however before this stage, because of development in designing and constructing of stilling basin, using stepped spillway had been outdated for a period of time. But recent progress in new technology such as roller compacted concrete (RCC) caused a new attention toward stepped spillway.

The flow over a stepped spillway could occur in three different types: nape, transition and skimming flow. Therefore, the investigation of hydraulic behavior of the flow over this kind of spillway becomes complicated. On the other hand, because of the air entrainment, turbulence and high interaction between air and water, accurate flow understanding and visualization is required for safe and reliable design of stepped spillway..

The spillway should pass the designed flow without causing any damage to the structure and the surrounding environment. Water energy should be properly dissipated to avoid dangerous damage at the toe and downstream of the spillway. One choice is to establish a stilling basin at the downstream of the spillway. There are different types of energy dissipaters that some of them are as follows; stilling basin type I, type II, type III, type IV, Solid Bucket and Slotted Bucket. The type of stilling basin is chosen according to the hydraulic characteristics of flow as well as economical and surrounding conditions. Another method is to dissipate the energy along the spillway by adding appropriate type and number of steps on the spillway to intensify turbulence of the flow and consequently increasing the energy dissipation over the spillway. In this condition, the dimension and the cost of downstream dissipater structure will be reduced.

In 2002 Chen et. al claimed that they had numerically simulated *turbulent* flow over stepped spillway for the first time. They applied k-ε turbulent model in their simulation [1]. In 2005 Tabbara et. al simulated the flow over stepped spillway without considering the air entrainment phenomenon, a finite element based software (ADINA)