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Numerical Modeling of Flow Field in Morning Glory Spillways and Determining Rating Curve at Different Flow Rates

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Abstract

Morning glory spillways with drop inlets are normally employed in dams built on narrow valleys or placed on steep slopes. In Iran, morning glory spillways have been commonly used in large Dam projects such as Sefidrood dam, Alborz dam, and Haraz dam. Physical models should be built to accurately determine hydraulic parameters of the flow and flow field in spillways. Establishment of a physical model involves extravagant costs and conditions that cannot be justified in some cases. Therefore, suitable numerical models can be proposed for such circumstances. Using FLOW3D numerical models, 3-dimensional numerical modelling of the flow was calibrated and validated by experimental information associated with morning glory spillway of Alborz dam and accuracy of numerical modelling was determined by relative error of numerical model. So it was attempted to determine flow pattern and control conditions of morning glory spillways in different modes using boundary conditions, inlet conditions and grid spacing of flow field and project rating curve of morning glory spillways. According to the results of numerical model, relative error of numerical modelling equals 6.4% for calculating discharge rate of the spillways. Numerical modelling error is 7.6% for determining depth parameter of the flow in spillway crest in comparison with experimental results.

Keywords: Morning Glory Spillway; Rating Curve; Numerical Model; Alborz Dam; FLOW3D.

1. Introduction

Morning glory spillway is a roofed conduit that quickly transfers the flow from an upper level to a lower level. This type of spillway is similar to siphon spillway but it performs different from siphon type. These spillways are not only used for dams, but also to control erosion of structures and highway culverts. Using this type of spillway is cost-effective in dams having steep abutments over narrow valleys or a diversion tunnel to transfer water flow to downstream of the dam. Moreover, morning glory spillways transfer the flow from upstream to downstream level (from catchment basin to tunnel drainage system in mountainous regions) in storm water drainage systems or water conveyance system. In such cases, morning glory spillways are employed with certain types of basins called "vortex basins" which give the flow an angular velocity leading to a circulating flow in glory hole. A variety of researches such as experimental studies, numerical modeling and simulations, analytic studies, etc. have been conducted on morning glory spillways. Here, it is attempted to present a set of the most important and recent studies in this field.

Ervine and Ahmed (1982) studied on flow aeration characteristics in a vertical nappe shaft [1]. In 2006, Zhao conducted experimental studies on hydraulic parameters of flow in morning glory spillways under nappe flow conditions [2]. Nohani and Mousavi (2009) investigated impact of number and thickness of vortex breaker blades on strength of spiral vortices and efficiency of the spillway discharge system by making a physical model of morning glory spillway and conducting experiments. The results showed that discharge coefficient of morning glory spillway enhanced up by 20% via increasing number of blades and 9% via increasing both number and thickness of blades [3]. In a study, Nohani and Naqshineh (2013) explored into effect of number, thickness and angle of vortex breaker blades

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