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Numerical Detection of Cavitation Damage on Dam Spillway

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Abstract

The present paper deals with the numerical detection of cavitation damage level and location on dam spillways. At first, flow over a spillway was simulated using the computational fluid dynamics method. The flow characteristics such as pressure, velocity and depth through the spillway have been calculated for five different flow rates. Since the actual flow is turbulent, the RNG turbulence model has been used for simulation. The numerical results of flow characteristics including flow depth, velocity and pressure were compared with the available results of the hydraulic model tests. The numerical results agreed well with the experimental data, and reasonable values for the normalized root mean square error (NRMSE= 0.0476) and coefficient of determination (r^2=0.8354) indicated that the numerical model is accurate. Finally occurrence of cavitation damage to the Doosti dam spillway was investigated. Based on cavitation index, five different damage levels from no damage to major damage have been considered. Results showed that the spillway may be at the risk of cavitation damage, and the serious damage can occur at ending parts of the structure.

Keywords: Spillway; Cavitation Damage; Cavitation Index; Numerical Modeling.

1. Introduction

Spillways are important hydraulic structures that play a remarkable role in safety and stability of dams. They are designed to prevent overtopping of dams and provide sufficient safety and stability during floods. High flow velocities on dam spillways could lead to low pressure and create cavitation. Cavitation is one of the most complex phenomenons affected on the spillway, and it causes damage on the structure over time [1, 2]. Occurrence of cavitation can be a function of pressure and velocity, boundary roughness, operation duration, the amount of dissolved air in the water and strength of materials from which the boundary is constructed [3].

For a long time, problems related to cavitation phenomenon on hydraulic structures especially dam spillways, have been one of the important engineering challenges all around the world, and various efforts have been made to investigate the mechanism of cavitation damage on dam spillways. Experimental modelling such as Hay [4], Nie [5], Dong and Su [6] and Frizell et al. [7], has successfully investigated cavitation damage on spillways under controlled laboratory conditions. Moreover, using numerical modeling can be a powerful tool for investigation of flow characteristics, for example, Savage and Johnson [8], Qian et al [9] and Zhenwei et al [10].

Recent development in computer science and numerical techniques has advanced the use of computational fluid dynamics (CFD) as a powerful tool for flow simulation over spillways. Computational fluid dynamics (CFD) is a numerical method used to solve problems involving fluid flow. It can provide a faster and more economical solution than physical models; therefore engineers are interested in verifying the capability of CFD softwares [11].

In this study, to investigate cavitation damage on the Doosti Dam spillway located in Iran, the Flow-3D software has been used to simulate flow over the spillway. Flow characteristics over the whole spillway have been determined, and the accuracy of the results has been examined by making comparison of the numerical model and available experimental tests. Finally, the cavitation damage levels and locations were predicted along the spillway.

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