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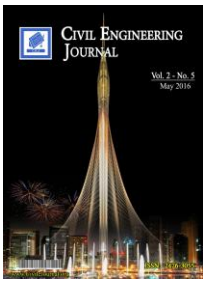

Numerical Study of Energy Dissipation of Pooled Stepped Spillways

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Abstract

Water transferring to the dam downstream creates high levels of kinetic energy. Stepped spillways are amongst the most effective spillways in reducing the kinetic energy of the flow moving towards the downstream. The geometry of the steps in stepped spillways can affect the reduction of kinetic energy of the flow transferring to the downstream. Recently pooled configurations have been more prevalent than smooth ones because this kind of spillways could have more dissipation. Therefore, in this study the effect of different number of pooled steps and discharge on flow pattern especially energy dissipation was investigated. The VOF method was used to simulate the flow surface and the k-ε (RNG) turbulence model was used for flow turbulence simulation. Comparing the results obtained from the numerical simulation with the experimental data indicated an acceptable level of consistency. Comparing the obtained results showed that decreasing the number of the steps of pooled stepped spillways reduced flow velocity and increased the relative energy dissipation at the end of the spillway. Decreasing the number of steps increased the turbulent kinetic energy value. Also, the maximum turbulent kinetic energy was obtained near the step's pool. Moreover the results indicated that the value of turbulent kinetic energy increased along the spillway.

Keywords: Three-Dimensional Simulation; Stepped Spillway; Energy Dissipation; Flow Patterns; Turbulent Kinetic Energy.

1. Introduction

One of the objectives of designing spillways is to transfer water flow to the dam downstream. Transferring water flow to the downstream creates high levels of kinetic energy. This energy can damage the spillway downstream if it is not somehow reduced. Stepped spillways which have been used for 3500 years [1] can reduce this energy and the dimensions of the downstream stilling basin [1-4]. The flow passing over stepped spillways create three types of flow pattern: nappe, transition, and skimming flows [5]. The formation of these three patterns on the stepped spillways depends on the height and length of the steps as well as the flow discharge [1, 6-8] Recently, construction of numerous stepped spillway on gravity dams [9] and this fact that stepped spillway perform desirably in energy dissipation has motivated researchers to experimentally study the flow characteristics on stepped spillway. The amount of energy dissipation has always been focused upon in most of the researches carried out on stepped spillways [10-12]. Chinnarasri and Wongwises [13] examined the flow patterns and energy dissipation and came to the conclusion that the geometry of the steps affects energy dissipation. Furthermore, energy dissipation increases as the number of the steps increases for a specific discharge with a constant step height. Comparing the relative energy dissipation over a stepped spillway with different steps height along the spillway by Felder and Chanson [14] indicated that energy dissipation is insignificant over stepped spillways with uniform step height in comparison with stepped spillways with non-uniform step heights. Felder et al. [7, 8] Felder and Chanson [15], Thorwarth [16] and Kokpinar [17] conducted experimental studies on flat and pooled stepped spillways. Comparing the results demonstrated that the number of the

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