Shahid Chamran University of Ahvaz
Irrigation Sciences and Engineering Vol. 41, No. 2, Summer 2018, p. 93-105

EXTENDED ABSTRACT

Numerical Simulation of Aerator ramp influence at Bed and Spillway's Wall Duct on Vacuum Creation Index using Flow 3D Model

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Received:1 March 2016 Accepted:23 January 2017

Keywords: Input air concentration to flow, Spillway, Aerator Ramp, Vacuum creation.

Abstract

In the present research, the flow on a free dam is modeled in 3D environment of Flow-3D software, then the software results were validated in comparison with results obtained from the physical model. Finally, the effect of various types of ramps on effective factors of vacuum creation was scrutinized. The results for vacuum creation index and air concentration existing within the flow revealed that a spillwaywith ramp at the bed and a wall equipped with duct, and a spillway with ramp at bed and wall, leads to %22, %22 and %19 increase in vacuum creation index, respectively.

Introduction

In places where the flow velocity is high, due to the unevenness of the spillway bed , the streamlines are separated from the bed, and at the downstream area, the pressure drop occurs and ultimately leads to the destruction of the spillway bed (Raesi, 2011). Jonson (1963) showed that, if the vacuum is formed inside the vortex core, the initial value of the vacuum should be less than or equal to one. Ohern and Katz (1986) have shown in their research that the beginning of the initial vacuum is in the three-dimensional structure inside the nucleus and not in the nuclei of the circuits. Savage and Johnson (2006) have found that a numerical model is useful for determining the flow rate and flow pressure by comparing the numerical and physical model of the flow over the Ojee spillway. Zhang, Wu and Dong (2010), with the help of the model made in the Hydraulic Laboratory of the University of Zhijiang, have studied the effect of air mixture in flow on the surface pressure and vacuum, and showed to have a positive effect on air concentration. ShafaiBajestan and NasrEsfahani (2014) investigated the cavitation phenomenon at the stilling basin with a rough bed and an abrupt drop. In this study, factors affecting the index of cavitation like velocity, pressure and the amount of air into the stream in five states of without aeration, with ramps on the bed, with ramps on the bed and wall duct, with a ramp in the walls, and also with a ramp on the bedand the wall was examined.

Methodology

The dam hydraulic model was built with a scale of 3 percent of the real dimensions 1: 33.33. The hydraulic model of the free reservoir dam flood control system was constructed by the Water

Research Institute with a scale of 1: 33.33 (100.3). Two similar aeration systems have been implemented at distances of 165 meters and 210 meters. The ramp height is 0.5 m and has a 7-degree angle (Fig. 1).

Figure 1- The Physical Model of Free dam spillway

FLOW-3D is powerful software in the field of fluid dynamics. One of the major capabilities of this software for hydraulic analysis is the ability to model free-surface flow by finite volume method. Since the distance from the starting point to the end of the ramp is 76.3 m, the ramp height difference at the end point is 0.5 m. The floor of the stairs continues horizontally to stop the overflow surface. The horizontal length of the stairs is 5.14 meters. The bottom of the abruptdrop is arranged 20 degrees in length from a circle with a two meters radius to the spillway bed. Figure 4 shows the shape of the ramp and the size of its components. The ramp is located at two points of intersection: the distance from the start of the overflow is 165 and 210 meters, and from the zero point of the model are 185 and 230 meters. The overflow image with a ramp on the floor is shown in figure 2.

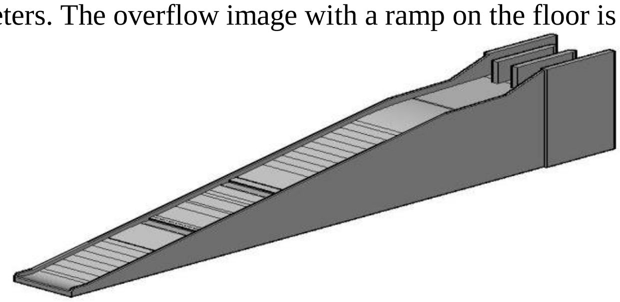

Figure 2 - Spillway with ramp on the floor

Results and discussion

The result of the spillway velocity, in which the mean velocity is in the vertical direction over the flow in the middle of the spillway along y, is presented as a figure and diagram at eight points over the spillway. Depending on the color, the velocity changes in different parts can be found in the longitudinal direction of the spillway. As ca be seen in the presented form, the ramp does not have a significant effect on velocity, but according to the formula for calculating the quadratic index, the same effect has little effect on the increase of the index and the reduction of the probability of the quasi-efficiency. According to the results obtained from the spillway software with ramps in the floor and duct in the wall and overflow with ramp on the floor and wall, they have the greatest impact on the slump in the middle of the spillway. Due to the criticality of the vacuum in the middle of the overflow, the pressure along the y in the middle of the overflow and in the longitudinal direction in eight points has been investigated and the results of the pressure in the overflow floor (below flow) are shown in the diagram below.

Conclusions

In this study, the flood-free flow spillway flow was 3D-based in Flow-3D software and then the accuracy of the software results was evaluated according to the results of the physical model. spillway with a ramp on the floor and wall in the first ramp, the air concentration in the bottom layer is 18.5 times and after the second ramp 7.5 times. The overflow with the ramp on the floor, at the checked location after the first ramp, is 18 times higher and in the area under investigation, after the second ramp, it has increased 4.5 times the air concentration compared to the ramp-free state, which maybe the two values exceed the actual amount, because the mesh sizes are such that the bed surface and the uniform wall are not modeled and cause the numerical model of the air to enter the wall from below the ramp.

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