3-D NUMERICAL SIMULATION ON UNITED DISSIPATOR OF FLARING GATE PIER AND STEPPED SPILLWAY

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The flaring gate piers(FGP) are combines with the stepped spillway and stilling pool. They form the united dissipation system. The study on FGP is primarily carried on in China and still mainly based on physical model test or prototype observation. Due to the complicated configurations and the highly irregular multiple free surface, the three-dimensional numerical simulation on the united system has not been reported. In order to inquire into the flow field characteristics of the system, the three-dimensional turbulence numerical simulation on it is presented in this paper.

For this type dissipator, the flows behave obvious three-dimensional characteristic. It is a typical two-phase flow of water and air and belongs to complex geometrical shape and strong non-linear problem, which is described as follow:

First, due to the inclined plane at the top and the enlargement in the middle of FGP, the flow over weir forms two thin and high nappes, named water wing, which stretch vertically, shown in Fig.1. There are three hydropneumatic interfaces at the top-surface, under-surface and both sides of the two water wings, separately. They contact with air in big region and collide mutually across the downstream steppes, then drop into the stilling pool.

Second, when the steppes are connected with the WES roller-way face, the outlet flow will no longer discharge along the ramp of the spillway. Due to the action of the vertical plane of the first step, the flows separate from the step surface so as to form the free jet. There is a hydropneumatic interfaces at the under-surface of the jet. Moreover, at the step surfaces, there is a region without water, shown in Fig.2. The air is supplied through the underside of the nappes.

Third, there is a big cavity in the downstream of FGP, shown in Fig.1. This cavity will play significant role in the aerification to the stepped spillway surface. The velocity vector sketch of the air phase in the downstream of FGP is shown in Fig. 3. It is obvious that the air rotates from the center to the both sides of the steps, and the cavity expands transversely so as to make aeration considerable.

For the united dissipation system in this paper, the key problems of the flow field simulation are: (1), the water wings; (2), the jets separated from the steps and the aerated cavity at the steps; (3), the mixture and diffusion of the water and air in the stilling pool; (4), the boundary conditions. Based on the current computer condition, the meshes with appropriate quality and scale are locally adopted in the major regions. The number of the mesh cells is about 1.13 million.

The calculated results are in good agreement with the experimental data. The simulated results indicated that on the juncture of the spillway surface and the first step there exists negative pressure, which has not been measured in previous experiments. Based on the position of the negative pressure obtained from the numerical simulation, measurement points were arranged in physical model. The results validate the existence of the negative pressure and are in good agreement with the calculated data.

The study results show that this type dissipator is effective for the problem of energy dissipation of overflow with high water head, large unit discharge and low Froude number.

Fig. 1 The water wing in the downstream of FGP surfaces

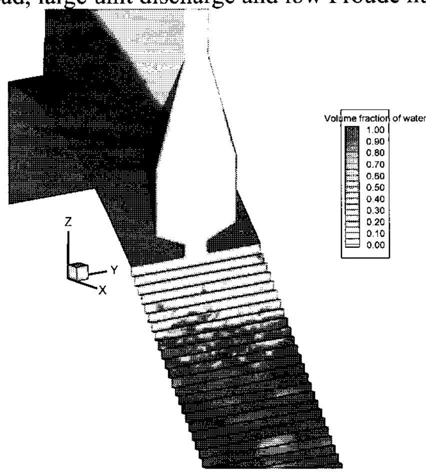

Fig. 2 The range without water at the first six step

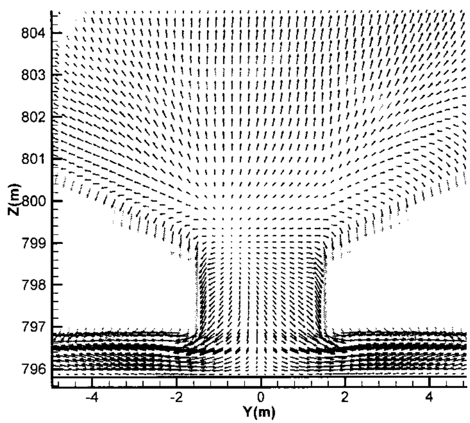

Fig. 3 The velocity vector sketch of the air phase in the downsteam of FGP