Free surface computations on dams

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ABSTRACT

For many fish species, powerplants are a barrier to their natural downstream migration. Numerical models are developed to better understand the complex flow field in hydropower forebays and tailraces, and thus reduce the fish stresses associated with the passage through dams.

Free surface models can simulate flows including the shape and evolution of the free surface. Improvements in the computer power have recently made it possible to tackle free surface computations of complex geometries with highly 3D flows. In the field of hydraulic engineering, the free surface models are not yet widely applied but steadily developed ([1], [3], [4], [5], [6]).

This paper presents a CFD model developed using the commercial code FLUENT to predict the flow field in hydraulic structures. The model is based on the Reynolds-Averaged Navier-Stokes (RANS) equations, with a standard $\kappa-\varepsilon$ turbulence model. The Volume of Fluid (VOF) method is used to predict free surface elevations [2]. A proportional controller is implemented in the model to achieve a target flow rate at the exits. The resulting equation is implemented using User Defined Functions (UDFs). The model is used to predict the flow field inside a fish surface collector at Rocky Reach dam. The model includes two dewatering channels, with side wall fish screens for each channel, and a pump station. The comparison of the numerical model results with depth averaged velocity field data and free surface elevation shows very good agreement. The model was also used to study the forces on a removable spillway weir structure and possible reduction of the spillway capacity during probably maximum flood in Little Goose dam. Free surface computations were also carried out to estimate the spillway jet regime and the free surface shape in tailraces. The model has demonstrated to work very well for flow regime predictions in Wanapum, Little Goose and Wells dams.

References

[1] Ferrari G. and M. Politano, Numerical simulation of free surface flows on a fish bypass, Computers and Fluids, (2008). In press.

[2] C.W. Hirt and B.D. Nichols, Volume of fluid (VOF) method for the dynamics of free boundaries, J. Comp. Physics, vol. 39, pp. 201-225, (1981).

[3] E.A. Meselhe and F. Sotiropulos, Three-dimensional numerical model for open-channels with free-surface variations, Journal of Hydraulic Research/De Recherches Hydrauliques, vol. **38**, pp. 115-121, (2000).

[4] B.M. Savage and M.C. Johnson, Physical and numerical comparison of flow over ogee spillway in the presence of tailwater, J. Hyd. Eng., vol. **132**, pp. 1353-1357 (2001).

[5] C.C.S. Song and F. Zhou, Simulation of free surface flow over spillway, J. Hyd. Eng., vol. **125**, pp. 959-967, (1999).

[6] C. Turan, P.M. Carrica, T. Lyons, D. Hay, and L.J. Weber, A Study of the Free Surface Flow on an Ogee-Crested Fish Bypass, J. Hyd. Eng., (2008). In Press.