3D NUMERICAL MODELING OF FLOW OVER WEIR-TYPE STRUCTURES

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Abstract

Weirs are constructed in rivers to modify the instream flow characteristics. A clear understanding of their effects on flow by different layouts of the structure is necessary to achieve desired results. Numerical simulations and laboratory experiments have been carried out to compare flow structures with linear and folded weirs. Laboratory experiments were conducted in straight and meandering channels. A three-dimensional finite volume model has been verified and applied for numerical modeling. A good agreement is observed with the simulated flow patterns and the laboratory measurements. The generation of secondary flow and large-scale 3d flow structures have been compared in the selected cases. The results clearly show the sensitivity of the flow pattern with changes in layout. The secondary flow strength and bed shear stress are enhanced significantly by folded weirs with sloping crest. They induce multiple vortices in the downstream channel and demonstrate the scope of further manipulating the flow by changing the crest parameters in complex natural layout of channels including rivers with large sediment transport. Finally, the present results give insight about the internal flow structures downstream of the folded weirs that would guide their design as flow controlling, grade control and habitat enhancement device.

Keywords: Weir; Numerical modeling; 3d Flow pattern; Habitat enhancement.

REFERENCES

Breusers, H. N. C., and Raudkivi, A. J., 1991. Scouring, A. A. Balkema, Ratterdam.

Bunt, C. M., Cooke, S. J. and McKinley, R. S., 1998. Creation and Maintenance of Habitat Downstream from a Weir for the Greenside Darter, Etheostoma blennioides - a Rare Fish in Canada. Envir. Biol. of Fishes, 51, 297-308.

Cassidy, J. J., Gardner, C. A. and Peacock, R. T., 1985. Boarman Labyrinth-Crest Spillway. J. Hydr. Engrg., ASCE, 111(3), 398-416.

Fjellheim, A. and Raddum, G. G., 1996. Weir Building in a Regulated West Norwegian River: Long-Term Dynamics of Invertebrates and Fish. Regul. Rivers: Res. Mgmt., 12, 301-308.

Hay, N. and Taylor, G., 1970. Performance and Design of Labyrinth Weirs. J. Hydr. Div., ASCE, 96(11), 2337-2357.

Hey, R. D., 1992. River Mechanics and Habitat Creation. Fisheries in the Year 2000, K. T. O'Gardy, A. J. B. Butterworth, R. P. Spillett, J. C. J. Domaniewski, eds., 271-285, 1992.

Hey, R. D., (1996). Environmentally Sensitive River Engineering. River Restoration, G.

Petts and P. Calow, eds., Blackwell Science, Oxford, 80-105, 1996.
Kim, J. and Walters, R. W., 2001. Oxygen Transfer at Low Drops Weirs. J. Hydr. Engrg., ASCE, 127(7), 604-610.
Olsen, N. R. B., and Kjellesvig, H. M., 1998. Three-dimensional numerical flow modeling for estimation of maximum local scour depth. J. of Hydraulic Research, 36(4), 579-590.
Rosgen, D. L., 1996. Natural Channel and River Restoration. Short Course Notes, Wildland Hydrology, Pagosa Springs, Colorado.
Rosgen, D. L., 2001. The Cross Vane, W-weir and J-Hook Structures: Their Description, Design and Application for Stream Stabilization and River restoration. Proc. Wetland Engineering and River Restoration Conference, Reno, Nevada, ASCE, CD ROM.
Shields, F. D., Knight, S. S. and Cooper, C. M., 1995. Incised Stream Physical Habitat Restoration with Stone Weirs. Regul. Rivers: Res. Mgmt., 10, 181-198.
Tullis, J. P., Amanian, N. and Waldron, D., 1995. Design of Labyrinth Spillways. J. Hydr. Engrg., ASCE, 121(3), 247-255.
Watson, C. C., Walters, R. W. and Hogan, S. A., 1998. Aeration Performance of Low Drop Weirs. J. Hydr. Engrg., ASCE, 124(1), 65-71.
Wormleaton, P. R. and Soufiani, E., 1998. Aeration Performance of Triangular Planform Labyrinth Weirs. J. Env. Engrg., ASCE, 124(8), 709-719.
Wu, S., and Rajaratnam, N., 1996. Submerged Flow Regimes of Rectangular Sharp-Crested Weirs. J. Hydr. Engrg., ASCE, 122(7), 412-413.