Analysis of Hydraulic Flow Conditions in Vertical Slot Fish Passes

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INTRODUCTION

Vertical slot fish passes (Figure 1) are one of the most commonly used types for upstream/downstream fish migration. They are made of a rectangular canal with a tilted bottom that is divided into a series of pools using vertical slots. Cross walls can be made out of different materials, such as wood, concrete and steel, and must be high enough so that they are never overflown. Water flows through a series of vertical slots on the cross-walls from one pool to the next, where cross-walls function as flow constrictors, increasing flow depth and forming pools. The stream forms a strong vortex in the pool between the two vertical slots, where its energy is dissipated. Differences in water level between individual pools govern the maximum flow velocities, and it must not exceed 0.2 m.

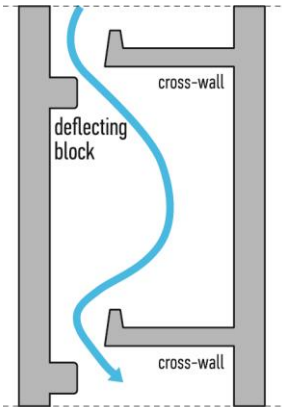

Figure 1. Layout of vertical slot fish pass (according to FAO, DVWK 2002)

METHODOLOGY

This paper presents analysis of hydraulic flow conditions in the vertical slot fish pass to accommodate upstream and downstream migration of desired fish species. Hydraulic variables are determined using conventional empirical relations available from current literature (Table 1) and compared with the ones calculated using numerical models. Analysed dimensions of fish passes are taken from recommendations in the literature, ranging from 1.5 to 4.0 m drops. Numerical models used are 2D and 3D models for detailed flow pattern calculation. Numerical models are calibrated based on hydraulic variables values available in literature to obtain benchmark data. Afterwards, using same numerical model's results were obtained for a range of fish pass geometry through varying slope and width and hydrological events through varying discharge. Coarser 2D numerical model is used for calculating stationary values of hydraulic variables on the entire fish pass domain, while 3D model is used for detail flow field calculation within characteristic section of the fish pass. Results obtained from 2D model are used as initial conditions for 3D model in order to achieve model stability.

Table 1. Minimum dimensions for slot passes with one slot (according to FAO, DVWK 2002)

		Fish species
		Grayling, Chub, Bream, others
Sloth width		0.15-0.30
Pool width		1.20-1.80
Pool length		1.90-3.00
Length of projection	[m]	0.16-0.18
Stager distance		0.06-0.14
Width of deflecting block		0.16-0.40
Min. depth of water		0.50-0.75
Discharge	[m^3/s]	0.15-0.40

RESULTS

Resulting flow field for range of discharges and cross-wall geometry is plotted against flow depth and fish pass slope as a scatter-plot. Scatter-plot vertexes are used for nonlinear curve fitting in regression analysis to generate mathematical function from which contours of resulting flow velocity are derived. From these curves target velocity can be isolated and used to obtain optimal dimensions of fish pass sections for desired application.

CONCLUSIONS

From numerical simulations covering range of fish pass geometry and flow boundary conditions resulting velocity contours can be defined that represent flow velocity on characteristic sections of fish pass.

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REFERENCES

FAO, DVWK (2002). Fish passes - Design, dimensions and monitoring, Food and Agriculture Organization of the United Nations (FAO) in arrangement with Deutscher Verband für Wasserwirtschaft und Kulturbau e.V. (DVWK) (German Association for Water Resources and Land Improvement), Rome.