Analysis of Hydraulic Flow Conditions in Pool Fish Pass

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INTRODUCTION

Pool fish passes

The basic idea of designing a pool fish pass is to divide canals into pools by building vertical cross-walls that ensure a gradual drop from headwater to tailwater. The flow is possible through openings in cross-walls or through the overflow and potential energy is dissipated gradually pool by pool. (Figure 1) The fish migrate from one pool to another through the openings (at the bottom of the cross-walls) or over the overflow. They overcome higher speeds when they pass through the openings while the pools serve as resting areas. The prerequisite for the passage of all migratory species and not just fish is to design rough bottom with a natural aggregate. The pool fish passes are usually straight layouts but given the available space and height to overcome there are situations where they have several 180 degree fractures.

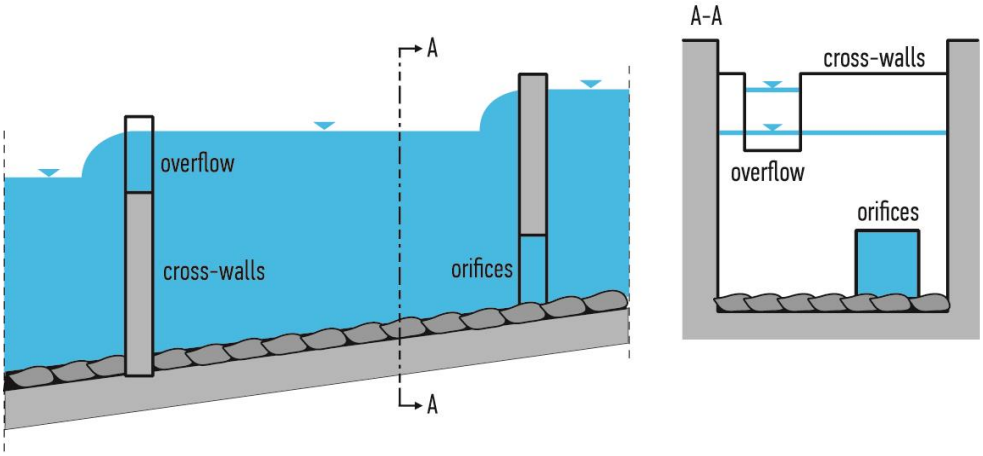

Figure 1. Scheme of pool pass with corresponding markings (according to FAO, DVWK 2002)

When designing a pool, dimensions that provide enough space to move or rest for fish but can also dissipate water without major turbulence are taken. Characteristics of the expected species and the number of migratory fish are also taken into account. The recommended lengths of the pool are between 1 and 2.25 m and the slope for them ranges from 1:7 to 1:15. The most important parameters for the poll fish pass to function are the flow rate, which cannot exceed 2 m/s in the passes, ensuring a minimum flow and volumetric power dissipation, which cannot exceed 150 W/m^3 or 200 W/m^3 for salmonid species.

Hydraulic flow conditions

This paper presents analysis of hydraulic flow conditions in the fish pass to accommodate selected fish species. Hydraulic variables are determined using conventional empirical relations available from current literature 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. Recommended dimensions for pool passes (according to FAO, DVWK 2002)

		Fish species	
		Upper trout zone	**Grayling, Chub, Bream, others**
Pool dimensions [m]	Length	>1,0	1,4-2,0
	Width	>0,8	1,0-1,5
	water depth	>0,6	0,6-0,8
Orifices dimensions [m]	-	0,2x0,2	(0,25-0,35)x(0,25-0,35)
Discharge [m^3/s]		0,05-0,1	0,08-0,2
Max. difference in water level [m]		0,20	

METHODOLOGY

Resulting flow field for varied range of discharge and 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 for fish pass sections.

ACKNOWLEDGMENTS

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REFERENCES

FAO, DVWK (2002). Fish passes – Design, dimensions and monitoring. FAO (Food and Agriculture Organization of the US), DVWK (German Association for Water Resources and Land Improvement), Rome, Italy.