Aeration and two-phase flow characteristics of bottom outlets

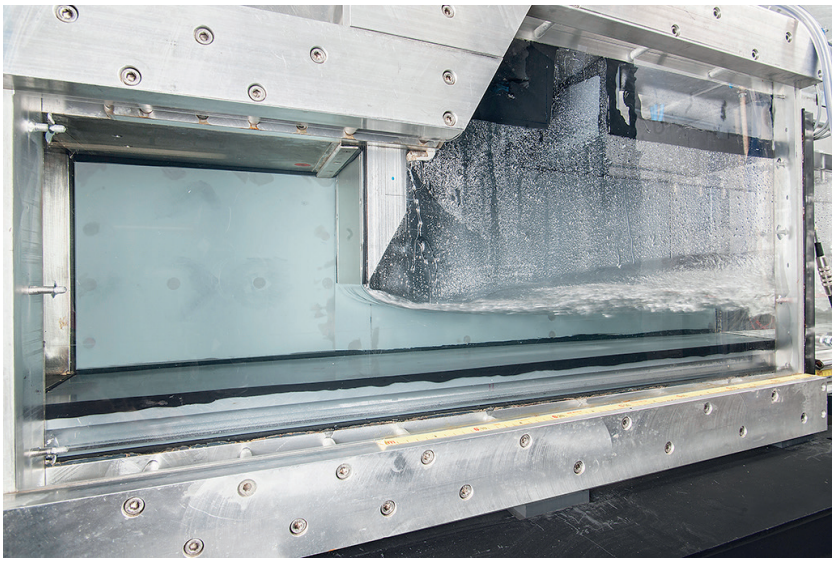
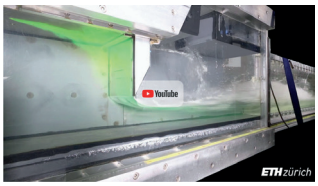


Fig. 1: View of the gate chamber in the hydraulic scale model. Flow direction is from left to right.

Bottom outlets are a key safety device of most dams serving the purpose of discharging water from its lowest elevation in a timely and quantitatively defined volume without causing damage. The free surface flow downstream of the gates results in considerable air entrainment and air transport and consequently negative pressures along the bottom outlet. Therefore, the gate chamber is equipped with an aeration conduit that guarantees sufficient air supply into the bottom outlet just downstream of the gates.

Although the aeration processes of free surface flow as e.g. along chutes is generally understood, the air flow in a bottom outlet corresponding to tunnel flow is complex and has not received much research activity in the recent past. Furthermore, the existing design criteria for the air demand of a bottom outlet show a large scatter and do not allow for a coherent design from the hydraulic point of view.

Therefore, the goal of this research project is to systematically investigate the high-speed two-phase flow characteristics in a bottom outlet by means of small-scale model tests. The main objectives include: (1) Investigation of all possible flow types in a bottom outlet depending on inflow Froude number, gate opening, aeration characteristics and tunnel dimensions; (2) Determination of vertical distribution of air concentration in the two-phase flow for free flow condition; (3) Investigation of air flow through aeration chamber and from tunnel outlet and their interaction with the two-phase flow in the bottom outlet; (4) Determination of the required air demand of a bottom outlet; (5) Preparation of design guidelines for the required tunnel cross section in the bottom outlet to ensure sufficient air flow and prevent flow chocking.



A video of the hydraulic scale model in operation

Data collected during a prototype measurement campaign are used to validate the results of the model tests. The measurements were performed i.a. in the bottom outlet of the Malvaglia dam in Switzerland with an energy head of 82 m w.c.

Keywords:	two-phase flow, bottom outlet, flow aeration, air demand, cavitation damage
Funded by:	Swiss National Science Foundation (SNSF) [grant 163415]
Duration:	2016 - 2019

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