New speed record set for measurements of water-air flows

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For the measurement campaigns, the research team first installed 16 custom-made probes in the tunnel spillway of the 225 m high Luzzone Dam. Credit: VAW, D-BAUG / ETH Zurich

For the first time, researchers at D-BAUG have measured air-water flows with velocities exceeding 40 m/s. To this end, two challenging measurement campaigns were carried out in the tunnel spillway of a 225 m high dam, for which special probes first had to be developed. With the new data, existing design guidelines can be validated, and so-called

scale effects can be assessed more accurately. This is relevant for the safe operation of hydraulic structures.

High-velocity air-water flows often occur in hydraulic structures such as spillways or low-level outlets at dams. Air entrainment affects the flow properties of the air-water mixture and must therefore be considered in the design of such structures. Existing design guidelines are primarily based on small-scale model tests. However, since certain relevant processes cannot be scaled arbitrarily, so-called scale effects may occur when upscaling from the lab to prototypes. Validation data from prototypes are therefore all the more important for the safe design of dams and hydropower structures.

However, due to the high effort involved, such in-situ measurements of air-water flows are quite rare. The last comparable measurements date back to the 1970s, where flow velocities of around 20m/s were achieved—a range that can now also be investigated in small-scale models. During a three-year study, researchers from the Laboratory of Hydraulics, Hydrology and Glaciology developed special measuring instruments together with partners from the Water Research Laboratory at the University of New South Wales, Australia. The two measurement campaigns took place in 2019 and 2020 in the tunnel spillway of the Luzzone Dam in Switzerland.

The study is an important step toward a better understanding of scale effects for air-water flows. It confirms a good agreement with existing empirical design equations for some bulk air-water flow properties such as mean air concentration, while more detailed properties such as droplet size are significantly influenced by scale effects. Thereby, the study helps to improves design recommendations of safety-relevant hydraulic structures such as spillways and low-level outlets at dams.

The research was published in the *Journal of Hydraulic Engineering*.

More information: Benjamin Hohermuth et al, High-Velocity Air–Water Flow Measurements in a Prototype Tunnel Chute: Scaling of Void Fraction and Interfacial Velocity, *Journal of Hydraulic Engineering* (2021). DOI: 10.1061/(ASCE)HY.1943-7900.0001936