Sediment management during Grimsel reservoir emptying within the frame of dam heightening works (2009 - 2010)

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Introduction and objectives

Enlarging the reservoir's capacity is a key factor in better matching energy supply to demand. To this end, the Grimsel reservoir will be emptied in order to heighten the existing dams. Emptying process occurs through a deviation gallery during wintertime, when minimum incoming upstream afflux is expected. This results in flushed sediments towards the Räterichsboden reservoir about 1 km downstream of Grimsel, during emptying and construction time. This can create turbidity currents and increase the amount of suspended sediment concentration in the downstream Räterichsboden reservoir.

To achieve a better estimation of the removed materials throughout pressure flushing from Räterichsboden bottom outlet, a physical model was built at the VAW-ETH Zürich and subsequently the physical model tests were simulated numerically at LCH-EPFL (Figure 1).

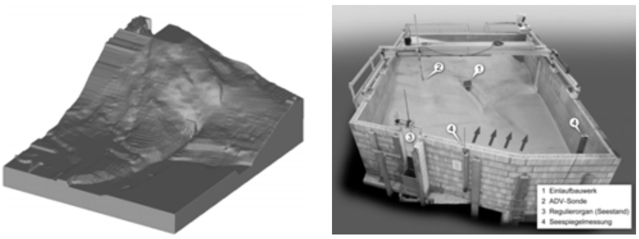

Figure 1 : Schematic view of Räterichsboden reservoir modeled by FLOW 3D at left and constructed model at the VAW-ETH Zürich

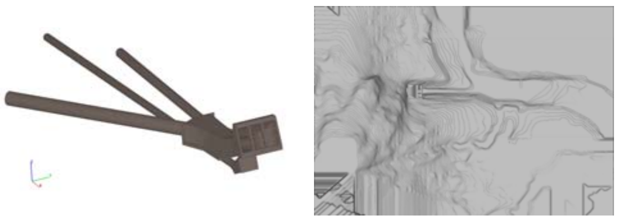

Figure 2 : Intake and bottom outlet, perspective and section view (left), plan view of the Räterichsboden reservoir and outlets together (right)

Numerical simulations

The numerical simulations were performed using the software FLOW-3D, version 9.4.2 from Flow Science Inc. in New Mexico, USA. FLOW-3D numerically solves the continuity and momentum equations using finite volume approximation. This work lies within the framework of LCH studies regarding sediment management during the foreseen heightening works of the Grimsel reservoir. All the major physical experiments are simulated numerically at the LCH, the results analysed and confronted to the physical model results. Finally, purged volume through the flushing process and angle of repose compared as well. Based on opening type of the bottom outlet gate, two major groups were defined as instantaneous opening (constant discharge from the beginning on) and gradual slow opening (rising from zero to a constant discharge.

Figure 3 shows the X-Z plane of the model at bottom outlet axis with packed sediment concentration contours in [g/l].

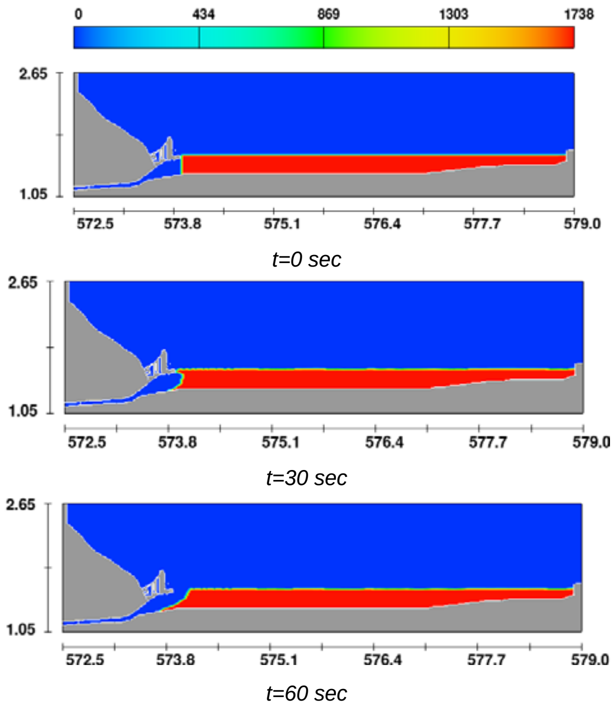

Figure 3 : Sediment flushing through the bottom outlet.

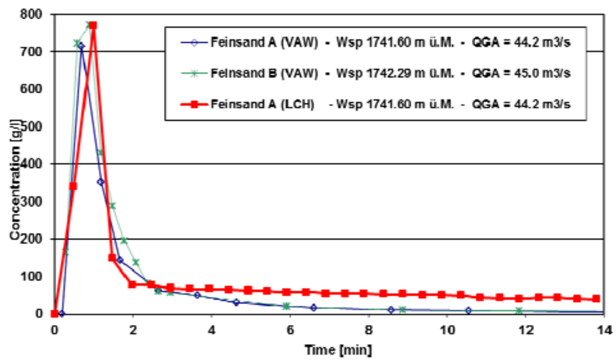

Figure 4 : Suspended sediment concentration for fine sand "Feinsand" A, B, (VAW experiments) and A (LCH simulation)

Test results

For practically all the tested scenarios, the simulated concentration curve matches almost perfectly with the extracted curve from the physical model. Through the flushing process a peak sediment concentration in the first two minutes with the magnitude of around 700 g/l is traceable immediately at the bottom outlet gallery. This high concentration during bottom outlet flushing decreases rapidly and becomes progressively zero after some 15 to 20 minutes at prototype scale. The flushed volume is extracted from the concentration curves by calculating the integral of the sediment concentration and discharge through the flushing time interval period.