Optimizing hydroabrasive-resistant materials at sediment bypass tunnels and hydraulic structures

Reservoir dams impound flowing water to balance a fluctuating water supply and demand, but suffer from sedimentation. Sediment bypass tunnels (SBTs) are an effective measure against reservoir sedimentation by diverting sediment-laden water past the dam and allowing for re-establishing the natural sediment continuity. However, high-speed sediment-laden flows in SBTs can cause severe invert abrasion, provoking high maintenance costs and putting SBT operation at risk. Due to the high cost of construction and maintenance, SBTs rarely deployed remaining a lack of knowledge. To find an economical and effective lining material on the tunnel inverts the operators have been testing different materials under operation, which have not led to a satisfying solution till this day. Overall, a great demand exits for economical and sustainable solution not only for SBT invert abrasion problem but also for hydro abrasive wear on hydraulic systems.

Up to a 2 m deep abrasion incision at the Val d'Ambra SBT into the concrete lining and underlying rock (M. Müller-Hagmann)

Abraded cast basalt tiles in the Pfaffensprung SBT (M. Müller-Hagmann)

The main objective of this research project is to quantify the correlation between the hydraulic operation conditions, sediment load, invert material and hydroabrasion. To this end, various invert materials, i.e. concretes, granite, steel and cast basalt, were installed and monitored in the Solis, Pfaffensprung and Runcahez SBTs in Switzerland. The abrasion patterns and rates, flow conditions, sediment transport rate and sediment properties in the rivers, reservoirs and SBTs were determined and their interrelations were analyzed with an emphasis on hydroabrasion, bypass efficiency and operating regime of the SBTs and respective reservoirs. Overall, this study provides new insights into the flow and sediment transport characteristics in SBTs and reservoirs and advances the understanding of hydroabrasion processes in high-speed sediment-laden open channel flows. The main result are the applicable recommendations with a focus on hydroabrasion and bypass efficiency. They contribute to a sustainable and efficient design and operation of SBTs and to the successful realization of the Swiss 'Energy Strategy 2050'.

Keywords:	Reservoir sedimentation, sediment bypass tunnel, invert abrasion, in-situ tests
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