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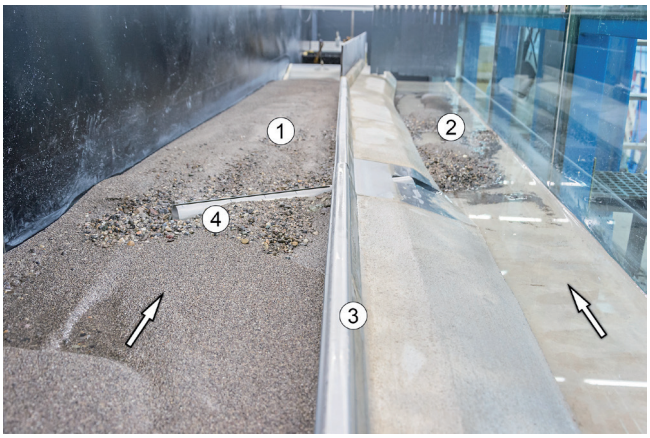
Hydropower Plant Turgi: Physical experiments on sediment bypass with a vortex tube

The hydropower plant Turgi is the second of four similar diversion power plants with side weirs along the last stretch of the river Limmat. A side weir of 390 m length separates the headwater channel from the residual flow reach. Bed load entrainment into the headwater channel causes accumulations along the channel and in front of the turbines. When necessary, these accumulations can be excavated and deposited in the residual flow reach, but a continuous diversion of bed load is economically and ecologically more desirable.

Currently, a number of weirs and a lack of bed load entrainment obstruct the sediment transport in the river Limmat and in consequence, a strong armour layer covers its bed. In the future, bed load transport in the reach of the hydropower plant Turgi will likely increase from a few m3/a to approximately 1′000 m3/a. This is due to several restoration measures planned in the upstream reach to enhance the bed load balance in accordance with the Swiss waters protection legislation.

View of the outlet of the vortex tube at the hydropower plant Schiffmühle from the residual flow reach

At the upstream power plant Schiffmühle, also operated by Limmatkraftwerke AG, the same problems occurred in the past and as a possible solution, VAW investigated a vortex tube in 2001. In the current design, the steel tube is embedded in the headwater channel and it leads through the side weir into the residual flow reach. It is equipped with a gate valve and only opened for discharges with sediment transport. The tube segment in the headwater channel has a longitudinal opening along the crest through which bed load is entrained. The combination of approach flow and pressure gradient along the tube leads to a vortex flow inside the tube that transports sediment into the residual flow reach.



View of the outlet of the vortex tube at the hydropower plant Schiffmühle from the residual flow reach

As the functioning of the vortex tube is strongly dependent on the local flow field, Limmatkraftwerke AG commissioned an investigation of the planned structure. The vortex tube was examined in a hybrid model using 3D numerical simulations by AF-Consult Switzerland AG and a sectional laboratory experiment at VAW. The sectional model at a scale of 1:25 was set up in a hydraulic flume and included an extent of 25 m width and 150 m length. Different vortex tubes were tested in a parameter study to determine their efficiency in terms of bed load diversion.

Keywords:	vortex tube, bed load transport, physical model
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