ETH zürich

Physical experiments on driftwood retention in combination with a new hydropower plant at the 'Kleine Emme' near Malters, Canton Lucerne

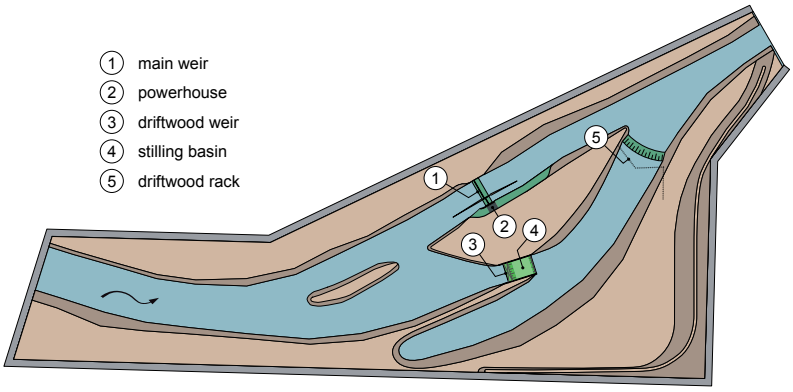

Fig. 1: General view of the physical scale model.

Fig. 2: Top view on the physical scale model obtained with a camera mounted at the laboratory ceiling to ensure continuous monitoring of the experiment.

The 2005 flood event caused large damages in many regions in Switzerland. During this event two bridges were damaged downstream of the planned driftwood retention rack in the 'Kleine Emme' river. Initiated by this event, the Canton Luzern introduced a flood protection concept for the complete catchment of the 'Kleine Emme'. The outcome for the Ettisbühl river stretch is a combined approach, including hydro power production (Fig. 1, (2)) regulated by a main weir (1), driftwood retention (5) controlled with an additional weir (3) and a stilling basin (4) as well as an optimized sediment management scheme.

The projected hydropower plant has been designed for a discharge of 16 m^3/s, resulting in an output of 872 kW. It will be positioned on the inner bend, replacing an existing block ramp. In case of flood events above 120 m^3/s, occurring driftwood is guided through the outer bend via an additional weir (3) into the driftwood corridor, where it is retained with the help of a v-shaped driftwood rack.

The Canton Lucerne has assigned the VAW to test and optimize the given configuration with the help of a physical model on a 1:50 scale with focus on flood protection aspects and the efficiency of the driftwood retention (Fig. 2). The model is equipped with a movable bed between the inlet and the two weirs and is approximately 16 m long and 8 m wide. At the inflow boundary, sediment is supplied with an automatic sediment seeding machine. Several ultrasonic level meters are used to continuously record water level elevations. A laser distance meter mounted on a 3-D positioning system measures morphological changes at the river bed.

After optimizing the geometrical conditions in the upstream section, long-term experiments have been performed, simulating 14 different 5- and 10-year flood events to estimate the evolution of the bed topography in the planned widening section upstream of the two weirs.

The different experiments show, that the intended efficiency of 50 % retained driftwood can be achieved. A proposed alternative design with a driftwood rack parallel to the flow downstream of the stilling basin is expected to be equally effective in terms of driftwood retention while even improving the situation with respect to flood protection. The unexpected high backwater level, observed with the originally projected design, can be explained with high flow velocities in the driftwood corridor leading to a piling up effect at the driftwood rack (Fig. 3).

Fig. 3: Driftwood retention at the rack showing a significant piling up effect leading to increased backwater.

Keywords: flood protection, driftwood, driftwood retention, bedload transport, river
Commissioned by: Canton Lucerne

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