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Flood protection Engstlige Frutigen: Physical model tests for large wood retention

The Engstlige River in Frutigen (BE) exhibits clear flood protection deficits. Already at medium flood events the capacity of the river reach through the village is exhausted and from 30-year flood on damages in the settlement are to be expected. For this reason, the flood protection plan is being elaborated. It is intended to ensure flood protection along the entire reach through the village and includes various measures along and upstream of the village. Among others, a large wood retention system is to be implemented upstream of the village (in the Grassi area). This should ensure maximum retention of large wood and at the same time have a minimal impact on the bedload transport. In addition, the system must continue to allow existing bedload management and must not interfere with the protected floodplain of national importance (Auengebiet von nationaler Bedeutung), which extends for about 7 kilometers to just before the settlement boundary of Frutigen.

In order to test different large wood retention systems, the river reach in the Grassi area (approx. 1 kilometer in length) was built in a physical model at a scale of 1:35. The study of variants showed that the river reacts very dynamically to retention systems due to its braided morphology. Nevertheless, a partial retention of up to 70% of large wood in an 100-year flood event could be achieved with different variants. A system with a rack parallel to the main flow direction turned out to be the best variant. It is to be installed at the transition from the braided reach into the channelized reach. A guiding element upstream of the rack ensures that the flow is directed into the rack. Compared to other systems, the parallel rack showed a reliable performance, low space requirements and medium costs.

During the model tests, different rack parameters were investigated including the rack length, bar spacing, rack geometry and guiding structure design. The final rack had a length of 115 m, bar spacing of 5 m along most of the rack length and 2.5 m at the downstream end of the rack. The guiding structure was built with heavy boulders and it shape resembles a groyne. However, it is so tall that its top is never submerged during extreme flood events.

The rack retains a volume of V_H = 2'300 - 2'600 fm^3 in the design scenario (100-year flood). This corresponds to an efficiency of η_H = 55 - 65 % with a design volume of V_H = 4'000 fm^3. The tests have shown that the rack functioned reliably and retained practically all the wood until it was filled. In the design scenario, the complete filling of the rack occured shortly before the peak discharge. From this point onwards, the wood was no longer held back but transported past the rack. An extension of the rack increased the retained volume to V_H = 3'400 fm^3 (η_H = 85 %). However, this layout is more expensive and occupies more space of the protected area. Due to these reasons, the extended rack was discarded in discussions with stakeholders.

In very extreme scenarios, the system showed robust behavior. Due to the increased discharges the large wood in the rack was pushed together more strongly. As a result, more large wood was retained on the same surface area (V_H = 3'100 - 3'500 fm^3 instead of V_H = 2'300 - 2'600 fm^3).

The greatest uncertainties in the dimensioning of the parallel screen certainly lie in the assumptions

regarding the transportation of large wood, i.e. in particular the expected volume of large wood. The estimation of the expected volume is very uncertain because the input of alluvial wood into a river system is hardly predictable and can occur very randomly. It depends on precipitation events, landslides and erosion processes as well as past flood events. For the Grassi site, it can be assumed that part of the transported large wood is deposited in the branched river section upstream of the retention rack. Such natural deposits of large wood have already been observed in past events. However, it is not possible to reliably estimate the extent of natural retention.

Despite these uncertainties, the proposed retention system will increase flood safety in Frutigen. The parallel rack reliably retains a considerable volume of floating debris and thus reduces the risk of large wood accumulations at the bridges in the village.

Depositions of large wood in the retention rack after the design event (100-year flood).

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