CERIS Civil Engineering Research and Innovation for Sustainability

Blocking probability of large wood and resulting head increase at ogee crest spillways

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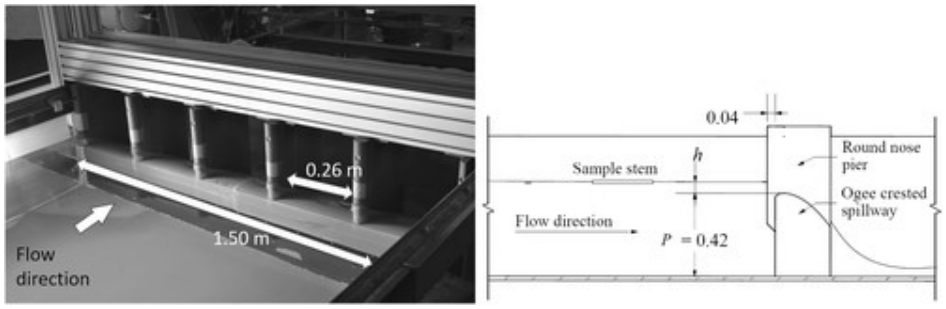
Summary

Large wood increases the hydraulic complexity of rivers, yet it may block and modify the flood discharge capacity of hydraulic structures such as bridges and spillways. When spillway blockage occurs, dangerous and hazardous situations have been observed at several dams. To assess the related risk, blocking probabilities and head increase quantifications for free surface spillways are needed. For this reason, the blocking probability of large wood and the resulting head increase is estimated, with an original systematic approach, for ogee crest spillways equipped with piers. The study is based on an experimental campaign using artificial stems. The evaluated variables related to large wood are: stem length, diameter and density, plus stem group size. The variables related to the structure and hydraulic conditions studied are: head, number of open bays and, bay width. A reservoir approach flow type is considered, implying small flow velocity.

A statistical analysis relating the number of experimental repetitions and accuracy in blocking probability estimations of large wood is presented. The evaluation analyses individual stems and groups. It is suggested to conduct at least 30 experimental repetitions for blocking probability estimations of individual stems to have standard errors smaller than 0.10 (with 90% confidence). For groups of stems, between 10 and 30 repetitions are suggested, according to the number of stems inside the group and the desired accuracy. For the first time, the influence of stem density on blocking estimations was evaluated for a reservoir approach. Results show that an increasing stem density increases the blocking probability of individual stems, when the stem length is greater than the bay width. Stems with a density close to water density, have higher blocking probability and may trigger wood jams when blocked. Regarding the head at the weir crest, the influence on blockage is not linear but usually an increasing head decreases the blocking probability. The influence of the number of open bays on the blocking probability was studied. Generally, for constant large wood characteristics and head, five open bays result in lower blocking probability than one open bay. Regarding the stem length related to the bay width, if the stem length is greater than the bay width, this parameter has limited influence on the blocking. Nonetheless, it was not possible to isolate the stem length influence as it was connected to the effect of stem diameter and head. The group size effect on the blocking probability of stems could be observed. For stems larger than the bay width and blocking probability lower than 0.80, an increasing group size increases the blocking of stems, compared to individual stems. The blocking probability of 4 stems can be the double of that of an individual stem for a constant head. However, increasing the group size from 4 to 16 stems has a mild influence on the blocking probability. Finally, varied groups of blocked stems allowed to measure the head increase in the reservoir. The head increase is influenced by the volume of blocked stems, jam shape, position and composition. A simple theoretical formulation to estimate the head increase as a function of an equivalent bay width is obtained. The formulation represents adequately the trend of head increase measured for blocked stems experimentally.

Keywords

Large Wood, blocking probability, discharge capacity, spillway, physical model.



Experimental set-up assembled at EPFL. Left: Front view of the physical model; Right: Longitudinal schematic view of the physical model (dimensions in meters).