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Slender Wood Jamming at bridge piers: Finite-infinite retention time regimes

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Wood accumulating at bridge piers is a safety risk as it leads to accelerated scour and flow blockage. Wood accumulation starts with a first wood element and the (retention) time that this element is retained controls if a jam accumulation further develops or not.

In flume experiments, we investigated the parameters and processes that determine the retention time of a single wood and developed a parameter-based predictive model for it. The experiments were based on eccentricity (the lateral distance between the centre of the wood and the centre of the pier) tests, measuring the retention time for varying eccentricities of the arriving element relative to the pier.

The experiments revealed that the accumulation of single wood element can be categorized into three different phases: impact, rotation, and separation. The first impact phase starts when the wood hits the bridge pier. In the subsequent rotation phase, the wood element rotates around the bridge pier and possible also slides. Finally, the wood element separates from the bridge pier.

A distinction can be made between an infinite and a finite regime. In the infinite regime, the rotation phase lasts very long and the wood element is in a metastable state. The diverging flow field around the bridge pier is key to the metastability since it causes stabilizing compensatory movements of the wood element around the bridge pier that include rotational swaying, vertical dipping or bouncing, and vibrations related to vortex shedding. The compensatory movements correlate with the Richardson number (the ratio of buoyancy force over inertia force), which is defined as the behaviour of the wood during a collision around bridge pier. The infinite regime only occurs for low eccentricities, i.e., eccentricities below one-third of the wood length.

In the finite regime, the rotation phase is rather short, and the wood element separates from the bridge pier after a short time. The finite regime is controlled by the friction between the wood element and the bridge pier, flow velocity and eccentricity

This study provides a conceptualization of the retention time of wood elements and a quantitative estimation of the retention time in the finite regime. These findings provide a step forward in explaining and predicting the processes and phenomena of wood jamming at bridge piers. The developed concept and will be further developed for the wood jamming involving multiple interacting wood elements.