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Fluvial dike breaching due to overtopping: how different is it from dam breaching?

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During floods in large rivers, casualties and extent of damage are often aggravated by breach formation across fluvial dikes. The most frequent cause of breaching is flow overtopping. Predicting the breach geometry and associated outflow hydrograph is of critical importance for estimating the inundation characteristics in the floodplain and the resulting flood risk.

Because fluvial dikes are built along a main channel that conveys flowing water, fluvial dike breaching differs from *dam* breaching, in which the embankment is built across the channel downstream of a reservoir. While a vast body of studies exists on dam breaching configuration (e.g., Schmocker et al. 2012, 2014, Müller et al. 2016), little is known on specific aspects of fluvial dike breaching.

We performed laboratory experiments that highlight the specific erosion processes governing fluvial dike breaching (Rifai et al. 2017a). The experimental setup includes a 10 m long and 1 m wide main channel, separated from a floodplain by a 0.3 m high dike of trapezoidal cross-section. The dike material was homogeneous and made of uniform sand. A rectangular initial notch was cut in the crest to initiate 3D breaching. The breach development was monitored continuously using a self-developed laser profilometry technique (Rifai et al. 2016).

The observations reveal that the breach develops in two stages. First, a combined breach deepening and widening occur, together with a gradual shift of the breach centreline toward the downstream side of the main channel. Later, the breach widening continues only toward the downstream side of the main channel, highlighting a significant influence of flow momentum in the main channel. Moreover, the breach cross-section is tilted toward the downstream end of the main channel, which is a signature of an asymmetric velocity distribution through the breach (Rifai et al. 2017b).

When the inflow discharge in the main channel is increased, the breach development becomes much faster (e.g., seven times faster for a 150 % increase in the inflow discharge). When an equilibrium state is reached at the end of the test, the breach centreline orientation is found consistent with the theory of flow over a lateral weir.

In the experiments, the boundary condition at the downstream end of the main channel is a lumped representation of river characteristics downstream of the breach section. In real-world conditions, these river characteristics influence the flow partition between the breach and the main channel. Therefore, we tested several downstream boundary conditions (perforated plane, rectilinear weir and sluice gate). For the same inflow discharge and water levels, they lead to significantly different breach geometries.

The findings of this research shed light on key mechanisms occurring in fluvial dike breaching, which differ substantially from those in dam breaching. These specific features need to be incorporated in flood risk analyses involving fluvial dike breaching.

This research also delivers a unique experimental database of high resolution continuous monitoring of the breach geometry under various flow conditions. The datasets are freely available for engineers and researchers willing to assess the performance of numerical models to simulate dike breaching and resulting flood.

References

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