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Probabilistic evaluation of riprap failure under future uncertain flood conditions: the case study of river Kleine Emme (Switzerland)

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Potential failure for river bank protection measures is a critical issue to be evaluated for the safety and stability assessment. Moreover, uncertainties associated to flood conditions and sediment transport in rivers, as a possible result of climate change in the future, affects the safety level of such riverbank protection structures as riprap and walls. Bank failure can lead to uncontrolled erosion and flooding with disastrous consequences in residential areas or in critical infrastructures. The probabilistic analysis of failure on different mechanisms due to possible flood events and sediment transport is a principal step to assess embankment stability in future scenarios.

Herein, a probabilistic risk assessment model to define the failure risk of river bank ripraps, developed based on Monte Carlo simulation and Moment Analysis Methods, is showed. This probabilistic simulation estimates the resistance of ripraps regarding varied flood and sediment transport scenarios in future. The failure probability of ripraps is assessed by a probabilistic function of the design safety factor. The probability of failure in different mechanisms such as direct block erosion, toe scouring and overtopping is defined by taking into account the modified bed-load transport due to a probabilistic function of the design discharge.

This evaluation method is applied to a Swiss river located in Canton Lucerne, the Kleine Emme. The results highlight the failure probability of riverbank riprap associated to different mechanisms individually. A risk map to represent the risk of total failure along a longitudinal profile of the river is proposed.