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Effects of river reach discretization on the estimation of the probability of levee failure owing to piping

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Over the centuries many societies have preferred to settle down nearby floodplains area and take advantage of the favorable environmental conditions. Due to changing hydro-meteorological conditions, over time, levee systems along rivers have been raised to protect urbanized area and reduce the impact of floods. As expressed by the so called "levee paradox", many societies might to tend to trust these levee protection systems due to an induced sense of safety and, as a consequence, invest even more in urban developing in levee protected flood prone areas. As a result, considering also the increasing number of population around the world, people living in floodplains is growing. However, human settlements in floodplains are not totally safe and have been continuously endangered by the risk of flooding. In fact, failures of levee system in case of flood event have also produced the most devastating disasters of the last two centuries due to the exposure of the developed floodprone areas to risk. In those cases, property damage is certain, but loss of life can vary dramatically with the extent of the inundation area, the size of the population at risk, and the amount of warning time available.
The aim of this study is to propose an innovative methodology to estimate the reliability of a general river levee system in case of piping, considering different sources of uncertainty, and analyze the influence of different discretization of the river reach in sub-reaches in the evaluation of the probability of failure. The reliability analysis, expressed in terms of fragility curve, was performed evaluating the probability of failure, conditioned by a given hydraulic load in case of a certain levee failure mechanism, using a Monte Carlo and First Order Reliability Method. Knowing the information about fragility curve for each discrete levee reach, different fragility indexes were introduced. Using the previous information was then possible to classify the river into sub-reaches having different classes of reliability.
This methodology was then applied to the Po River where the probability of failure in case of synthetic 100-year return period flood event was additionally calculated.
The results of this study pointed out how the fragility classes assessed for the Po are in agreement with the historical observations. Moreover, the choice in the discretization criteria may affect the resulting probability of failure along the river reach.
Classifying different levee reaches into different classes of fragility can be then used in a generic river reach where levee geometry is known. Furthermore, the proposed fragility analysis can support probabilistic flood risk mapping, monitoring and planning of maintenance works of levee systems.
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