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Probabilistic analysis of river levees under consideration of time-dependent loads

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In the analysis regarding the stability of river dikes, the interactions between the load magnitude of the flood level and the resulting percolation are found to be a highly relevant process. After all, the seepage line separates the cross-sectional area into the water-saturated and the unsaturated cross-sectional parts. For homogeneous levees, the position of the seepage line in the stationary case is imprinted in the system by the outer cubature and is well on the safe side for real flood events. In the non-stationary case, the position of the seepage line depends primarily on the changing water level of a flood hydrograph, the resulting water content and suction stresses in the dike, as well as the saturated permeability of the dike construction materials. In the current dimensioning practice according to DIN 19712 and the German DWA-M-507, the characteristic of the hydrograph is not directly applied. So far, for example, the resulting damming duration of a flood hydrograph is only considered indirectly.

This paper presents a methodology, which quantifies natural dependency structures for a selected dike section by synthetically generated dimensioning hydrographs in a probabilistic design. These results are then integrated directly into the geohydraulic process of water penetration. Based on selected water level and discharge time series at a dike section, flood waves can be described in five parameters using the extended flood characteristic simulation according to MUNLV¹. After successfully adapting suitable distribution functions, dependencies in the load structure are quantified in the next step using Copula function. Subsequently, any number of synthetic flood hydrographs can be generated by combining these parameters. In keeping with the principle of the Monte Carlo simulation, a sufficiently high number of synthetic events results in extreme conditions with a low probability of occurrence being reliably represented.

Using a developed routine, the process of moisture penetration for the individual flood hydrographs can be simulated and visualized in a transient, geohydraulically numerical model at different points in times. Finally, statements regarding the behavior patterns of the resulting seepage lines, based on the loading situation can be derived and predicted. Based on these results, a reliability analysis then shows the stability of the dike section under the given extreme conditions.

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