Estimating the effect of assumed initial damage to the hydraulic stability of pattern-placed revetments on dikes using finite element modeling

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Abstract

Initial damage, caused by previous wave loading or other events, might affect the hydraulic stability of pattern-placed revetments. Three common types of damage are considered in this study. The effect of this assumed initial damage on the hydraulic stability and failure probability of revetments is quantified using a FEM model. This model is developed using data from large-scale flume and field experiments. Using results from the FEM model, surrogate models are created to predict the effect of each type of initial damage on the hydraulic stability and failure probability. Through the use of these surrogate models, it is demonstrated that S-shaped deformation caused by filter migration around the wave impact zone has the largest effect on the hydraulic stability decreasing up to 30%, and failure probability per year increasing up to 10,000 times.

When the granular filling between the joints of the columns is washed-out, the stability decreases up to 29% and the failure probability increases up to 700 times. A missing column has a limited effect on the hydraulic stability and failure probability when there is no other (structural) damage. However, if it originates from underlying damage, it might be an initial sign of total failure of the revetment. This study demonstrates the effectiveness of finite element modeling for studying (damaged) revetments, which can be used to complement flume experiments. The results can be used to prioritize maintenance efforts in risk-based maintenance of pattern-placed revetments.

Keywords

Flood defenses, Dikes, Risk-based maintenance, Pattern-placed revetment, Wave impact, Finite element modeling, Surrogate modeling, Reliability analysis, Vulnerability

Elsevier, Coastal Engineering 189 (2024) 104484.