Quantification and reduction of uncertainty in the piping assessment

A comparison of uncertainty reducing strategies

In The Netherlands new flood safety standards were enacted in 2017 including new assessment methods. The WBI2017 describes methods to determine the probability that a certain failure mechanism will occur, which therefor involves a probabilistic approach. Piping is one of the failure mechanisms that contributes most to the probabilities of failure in the Dutch flood defence system. This process is currently modelled according to the WBI2017 using the “Sellmeijer model”.

Performing an assessment on the piping failure mechanisms involves different uncertainties that can affect the probability distribution of the dike’s resistance against piping. More uncertainty in the input of the model generally results in higher calculated probabilities of the dike being weaker or stronger than the calculated expected value. The focus is therefor on quantifying and reducing these uncertainties using different strategies. First a case was defined, including initial input uncertainties for the model. The effect of these initial uncertainties on the model output were exposed, using a fully probabilistic approach. Next, several strategies were defined to reduce these uncertainties. The effects of these strategies where then evaluated and compared to the initial case. Finally, the effectiveness of these strategies in the piping assessment were compared to each other.

Most uncertainty in the determination of the probability of failure for the case was caused by the model uncertainty coefficient, blanket clay layer in the hinterland and the sand submerged weight. The total level of uncertainty in the assessment was expressed in the characteristics of the probability distribution of the piping resistance, which had a 95% confidence interval of 5.62m. To reduce uncertainty, three types of uncertainty reducing strategies were defined: increasing measurement densities, improving probabilistic methods and continuous spatial measurements.

After implementation of the strategies and evaluating their effects, the following conclusion/recommendations were given:

- The use of continuous spatial measurement techniques showed to be the most effective strategy if a high level of uncertainty is present in parameters influenced by the thickness of impermeable covering layers in the fore- and hinterland.
- It is recommended to perform fully probabilistic piping assessments instead of semi probabilistic assessments because it allows for a closer approximation of the probability of failure and more straightforward implementation of uncertainty reducing strategies.
- Improving probabilistic methods in the assessment can be effective and require minimal additional effort and costs.
- Performing a decomposition of variance of the output in piping resistance identifies the origins of the uncertainties in the assessment. This can provide transparency and leads for the most effective strategies to decrease uncertainty in the piping assessment.
- By the use of a fully probabilistic approach, a degree of uncertainty in piping resistance can be given besides the calculated probability of failure. This way a decision maker has insight in the level of uncertainty which contributes to a transparent way of assessing dikes on the piping mechanism.

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