QUANTIFICATION OF UNCERTAINTIES IN SLOPE STABILITY ASSESSMENT AND STRATEGIES TO REDUCE THE UNCERTAINTY

FOR THE WBI2017 INNER SLOPE STABILITY ASSESSMENT

Dikes are essential for flood protection both in the Netherlands and worldwide. Although dike breaches are rare, a lot of effort is put in keeping the dikes at a desirable level of safety. One of the most dominant failure modes specified within the WBI is macro-instability of the inner slope. This failure mode includes the sliding of a large part of the dike's soil body due to insufficient shear resistance.

Due to spatial variability of soil and state properties and knowledge uncertainties, the assessment of slope stability is bound to uncertainties in the assessed stability. The level of assessed (legal) safety is thereby a combination of the inherent temporal variation of water levels and uncertainty in actual stability of the dike. This study quantified the uncertainty in assessed stability as spread in the safety factor using a Monte Carlo simulation and the D-Stability slope stability software. In addition, strategies to reduce the uncertainty were assessed for their effectiveness.

To quantify the uncertainty, a theoretical dike case was composed together with various types of uncertainties. Therewith, the uncertainty in input parameters was used to quantify the total uncertainty in the assessed stability. Using a Monte Carlo simulation method combined with a variance based sensitivity analysis, the magnitude of uncertainty was determined and decomposed to the influence of individual parameters. The uncertainty, expressed as the coefficient of variation, showed to be a nearly constant 9% of the mean safety factor for this case, independent of the outer water level. The 95% confidence interval for a given water level was more than twice as large as the range of the mean safety factor over the total range of the outer water level, indicating that the uncertainty is substantial.

The variance based sensitivity analysis revealed that the uncertainty in the assessed stability could be attributed to three main constituents. These were the model uncertainty parameter, the uncertainty in sub-soil stratification and uncertainty in soil strength and state parameters. Subsequently, three strategies were identified to reduce the uncertainty in the assessed stability. These were a less conservative modelling approach for uplift behavior, improved understanding of the sub-soil composition through point measurements and/or continuous spatial measurements and thirdly better estimates of soil strength and state parameters by acquiring more field measurements.

The effects were quantified by comparing the effects of the proposed strategies to the initial case. Reducing the uncertainty in the soil strength and state parameters showed to be most effective in reducing the uncertainty in the stability. Furthermore, reductions in the standard deviation of the stability can yield much larger reductions in failure probabilities, as failure lies in the tails of the distribution. This showed that the uncertainty in the stability can realistically be reduced, improving the safety assessment. This can identify weak spots or prevent unnecessary dike reinforcements.

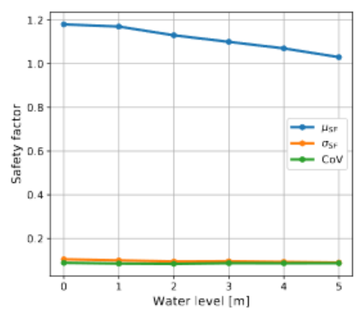

Figure 1: Mean, standard deviation and *coefficient of variation of the safety factor for different water levels*

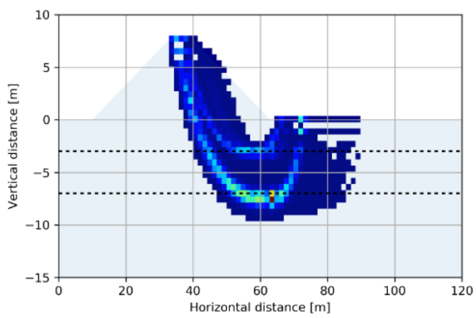

Figure 2: Variation in the location of the critical slip plane.

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