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BEYOND INNER SLOPE INSTABILITY: A METHOD TO QUANTIFY THE RESIDUAL DIKE STRENGTH BY WAVE OVERTOPPING

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Abstract

Climate change increases the risk of grass dikes being breached as hot weather weakens grass covers while more frequent high water is present. This can result in initial damage to the dike cover, in which case the dike does not fully breach. Understanding of the residual dike strength is essential from a flood risk perspective to efficiently design dikes against extreme events. This study assesses the residual dike strength by wave overtopping by evaluating a newly developed framework for the failure probability of overtopping waves of grass-covered river dikes. A method following this framework is used to derive fragility curves that describe the failure probabilities at varying water levels. To extend the current Dutch safety standards, fragility curves obtained by wave overtopping can be combined with the instability occurrence.

Keywords: damaged dyke, residual dike strength, macro-instability, wave overtopping, failure probability.

Method

The probability of failure at multiple water levels is computed using the framework of Figure 1, complementing findings of Van Der Krogt et al. (2019). An analytical erosion model (Van Bergeijk et al., 2019) is used with historic wave overtopping experiments to set up the model conditions. Using extreme wind statistics and grass strength distributions a Monte-Carlo-Analysis is performed with N = 10,000 storm events to assess erosion failure (Verdonk, 2020).

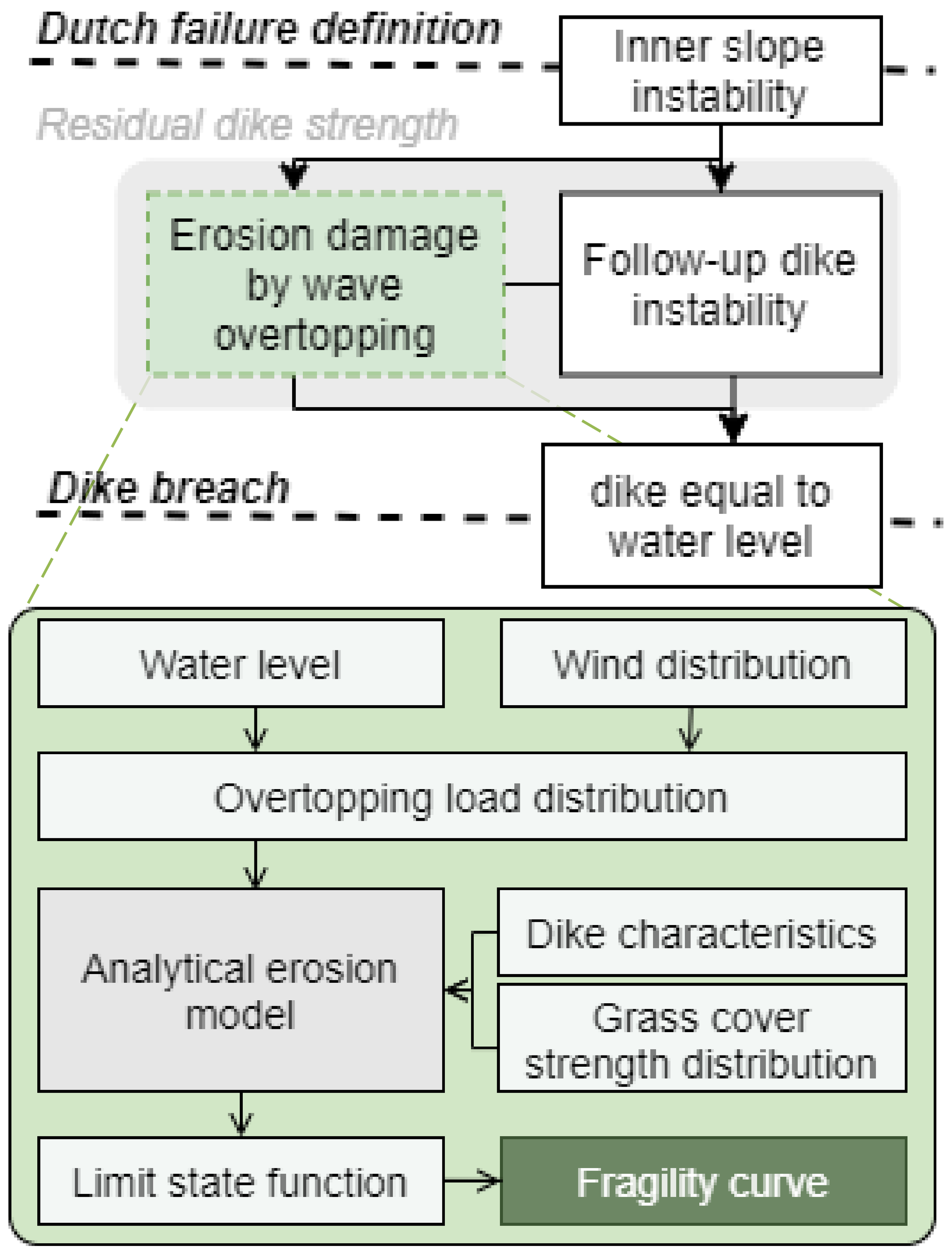

Figure 1: Assessment of inner slope failure with the (green) developed framework.

Results

- The failure probability decreases rapidly with an increasing free crest height (the dike crest and water level difference) (Figure 2).
- The damaged dike geometry is more vulnerable to failure by wave overtopping for an increasing free crest height (Figure 3).
- Clay quality of the cover layer has a major influence on the erosion failure occurrence. A sheared profile with a clay cover layer can fail 2-12 times faster than a regular dike

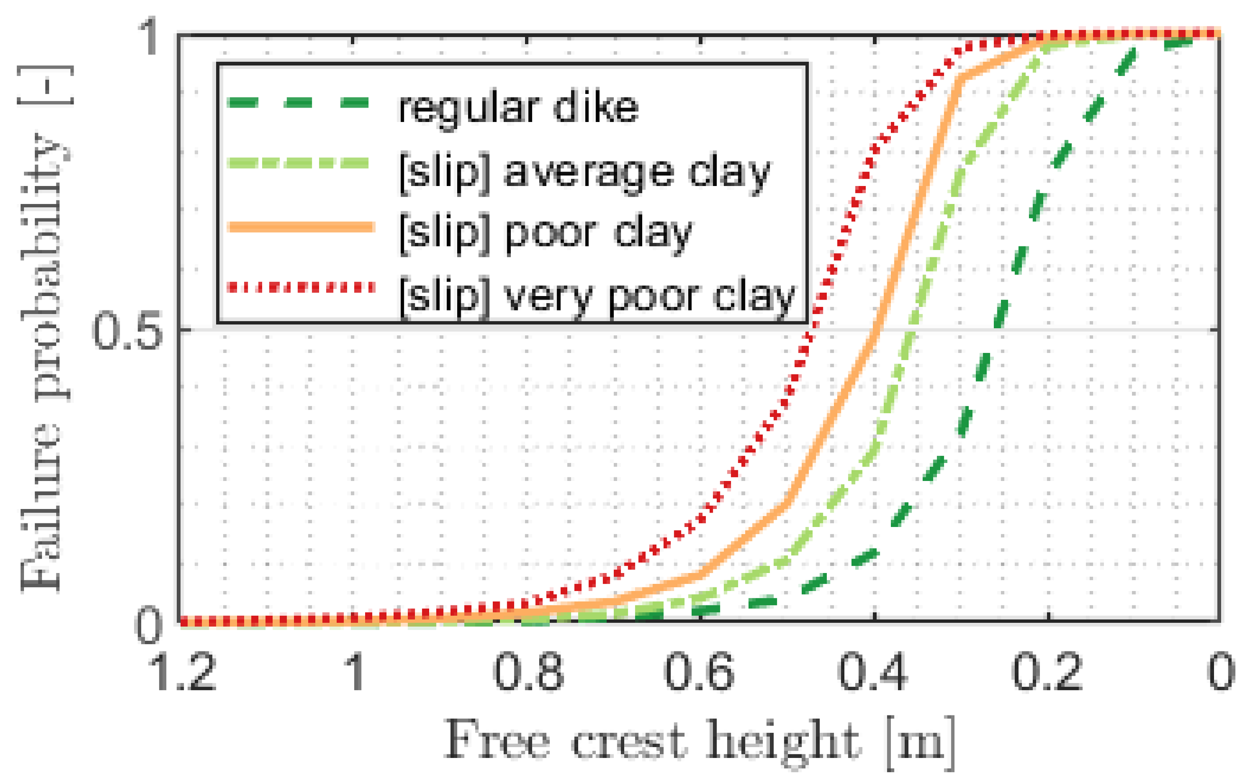

Figure 2: Fragility curves with failure conditions.

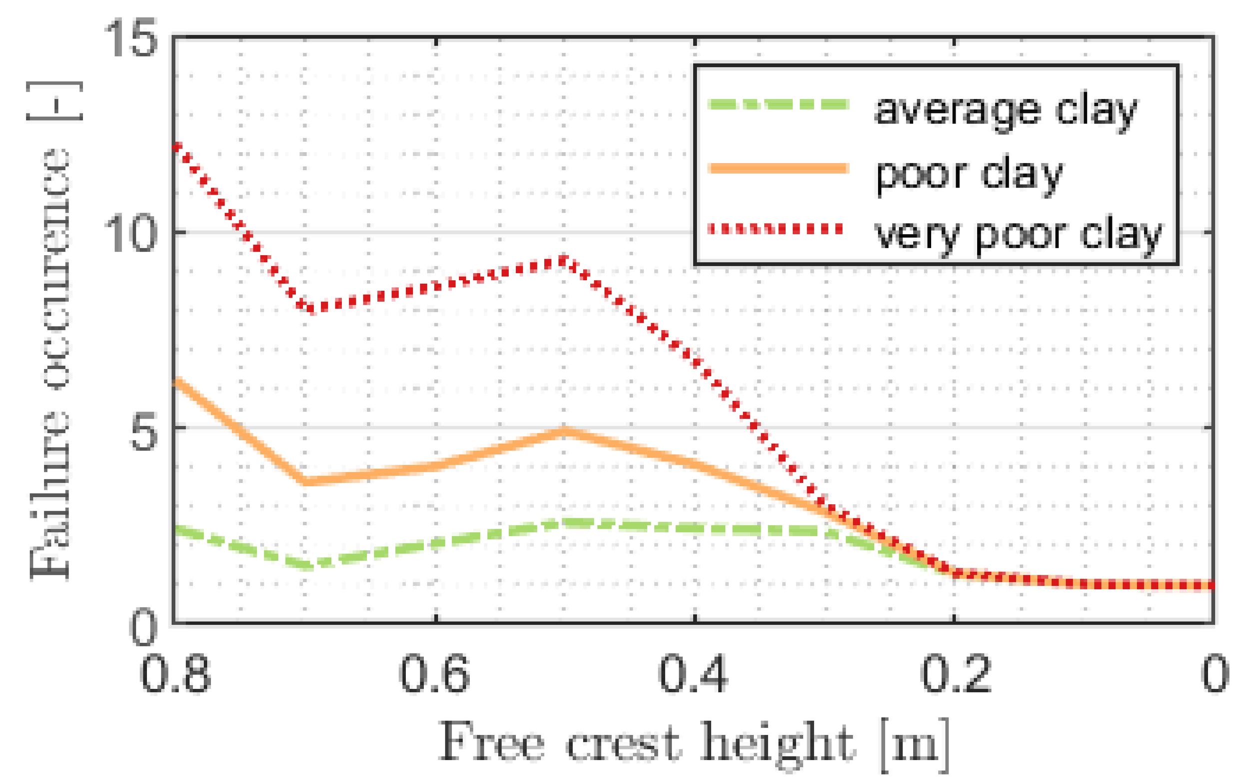

Figure 3: Failure occurrence with a slope instability compared to a normal dike.

Conclusions

From the results the residual dike strength after an initial slope instability is expected to be significant. This residual strength can be included in extensive probabilistic analyses for the assessment of safety standards. The results of this research show that there is a significant difference between the failure probability of regular and damaged dike profile and provide a method to perform a probabilistic assessment.

Bibliography

Van Bergeijk, V.M., Warmink, J.J., Frankena, M., & Hulscher, S.J.M.H. (2019). Modelling Dike Cover Erosion by Overtopping Waves: The Effects of Transitions. Hydraulic Engineering Repository, 1097–1106. https://doi.org/https://doi.org/10.18451/978-3-939230-64-9_110

Van Der Krogt, M.G., Schweckendiek, T., & Kok, M. (2019). Do all dike instabilities cause flooding? 13th International Conference on Applications of Statistics and Probability in Civil Engineering, ICASP 2019.

Verdonk, V.A. (2020). The impact of overtopping on the failure probability of slipped river dikes. Master Thesis, University of Twente. https://www.utwente.nl/en/et/wem/education/msc-thesis/2020/Verdonk.pdf