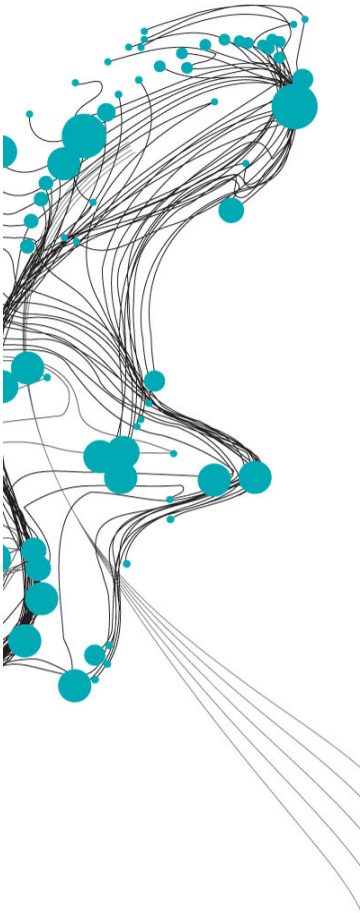
INCORPORATING RESIDUAL STRENGTH REGARDING CLAY RESISTANCE IN DIKE SAFETY ASSESSMENT

A CASE STUDY OF THE KETELMEERDIJK



The Netherlands is protected from flooding by an extensive network of flood defenses, which are continuously monitored, assessed, and reinforced as needed to ensure their stability. Every 12 years, a safety assessment is conducted on these defenses, evaluating various failure mechanisms against legal standards set by the Dutch Government. One such mechanism is the stability of revetments on the outer slope of a dike against wave impact. However, the erosion resistance of the clay layer and dike core is not currently assessed due to its complexity. It is assumed that dike failure occurs when the revetments fail.

This thesis explores why the dike body strength is not included in safety assessments, examines the possibilities and uncertainties of integrating this component, and proposes a methodology for its inclusion in Dutch dike safety assessments. This would enable a more accurate estimation of breaching risks, leading to more efficient dike designs and potential cost savings in future reinforcements.

The Ketelmeerdijk serves as a case study to evaluate the impact of including clay erosion in strength calculations. A model was developed to evaluate the erosion volume of the clay layer under normative hydraulic conditions. This model requires input on hydraulic loading (water levels, wave conditions) and dike properties (geometry, soil characteristics, current condition).

The study analyzed wave impact during a storm expected once every 10,000 years over 35 hours using BOI-compliant software. It identified specific failure moments for revetment layers (basalt and Basalton below the berm, grass cover above the berm), leading to clay erosion until the sandy core was reached. Clay erosion was modeled using methods from large-scale Delta Flume tests [1][2]. The methods showed to be most sensitive to the input from the hydraulic conditions, which makes this input crucial for an adequate estimation of the erosion volumes.

The research showed that the Ketelmeerdijk lacks sufficient residual strength on the upper slope, based on a normative storm. After 15.2 hours, clay erosion began following the failure of the turf and upper clay layers. The subsequent 4-hour peak load would erode 0.81 to 1.16 meters of the 1-meter thick clay layer.

Incorporating clay erosion into dike safety assessments more accurately estimates breaching risks and improves the strength assessment by over 125%. Although sand erosion contributes less to overall strength, considering residual strength in dike designs and reinforcements can enhance safety and yield significant economic benefits.

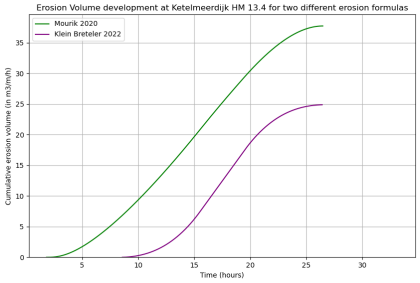


Figure 1: Erosion volume development for both methods of Mourik (2020) and Klein Breteler (2022).

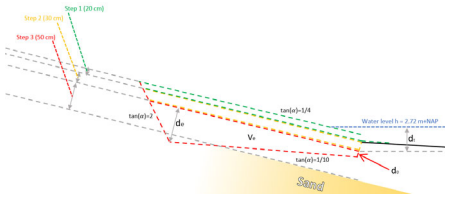


Figure 2: End situation after 10,000 years storm forced its way through grass cover, and clay cover below

[1] Mourik, G. (2020). Prediction of the erosion velocity of a slope of clay due to wave attack
[2] Klein Breteler, M. (2022). Erosie van kleibekleding met gras op boventalud van Waddenzeedijken

Jildert de Jong

Graduation Date:
5th of July 2024

Graduation committee:
University of Twente
Prof.dr. S.J.M.H. Hulscher
ir. N. van der Vegt

Waterschap Zuiderzeeland
dr. M. Visser

UNIVERSITY OF TWENTE.