Case Study: Lekdijk (Vianen, Utrecht)
Optimum levee width considering piping erosion

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CASE STUDY: LEKDIJK (VIANEN, UTRECHT)

CASE LOCATION

Along the river Lek, the northwest west section of the dijkring 16 in front of the city of Vianen, was insufficiently stable for the a plausible scenario of future climate change. Therefore it was decided that this section needed to be strengthened so that it could comply with the Dutch statutory safety requirements for the stability of the dike. Hence, a robust field campaign was performed along this dike section in order to collect field soil samples which will allow to validate the actual decision and optimize the future strengthening measures.

As an alternative to a traditional reinforcement measure Water Authority Rivierenland opted for an innovative solution: dike-nail-punching or 'dijkvernageling'. For this project, this meant that over a range of 250 meters 275 nails were drilled just above the closing level of the dike in three rows above each other. The nails were drilled in the dike by an anchoring drill, a kind of customized crawler excavator.

Despite the fact that this dike section was strengthened in terms of slope stability, a large amount of soil data was collected from the subsoil dike foundation which allowed to perform an statistical analysis between the collected samples. This analysis allowed to include the possible effects of correlation in the design of an hypotethical MFFD designed for the encountered conditions in this location.

(Source: www.waterschaprivierenland.nl)

OPTIMUM LEVEE WIDTH CONSIDERING PIPING EROSION

Based on the materials that are present in the flood defense, the resistance to failure mechanisms also changes as the deterioration rates change. In that sense, the optimum size of flood defenses can be better determined if the inherent uncertainty associated with the materials is reduced.

For the case of piping erosion, grains need to be lifted and transported to the hinter side of the defense for the erosion to progress. In addition, the permeability of the soil which represents the capacity of soil to allow water to flow through its pores, is highly determined by the representative grain sizes of that soil. This means that larger grains allow more spaces in between and consequently less resistance for water to flow. Both variables are involved in the physical process of piping erosion and both are correlated in an unknown degree.

Consequently, the correct choice of the degree of correlation between permeability and representative grain size during the probabilistic assesment will directly affect the MFFD geometrical choice, which determines the potential available space and the estimated MFFD reliability.This was concluded from a case study in a location along the Lek River in Utrecht Province (The Netherlands), where a large number of samples containing these parameters was available.

A hypothetical MFFD design wich complies with the actual safety standards (1/2000) for piping is found to require an average width of 200 meters. However, when permeability and grain size are highly correlated ($\tau \approx 0.692$) as found for the Vianen data set, a width of only 180 meters. For stricter safety standards such as the ones suggested as an educated guess without any scientific support, in the order of magnitude of 100 times less frequent, the obtained results where 200 meters with correlation and 230 meters without correlation as shown in Figure 2 below.

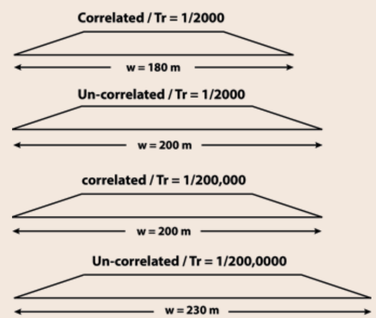

Figure 1 (page 42). River Lek at Vianen (Image courtesy Rijkswaterstaat beeldbank).

Figure 2 (left). Required widths (w) based on correlation and failure chance (Tr).