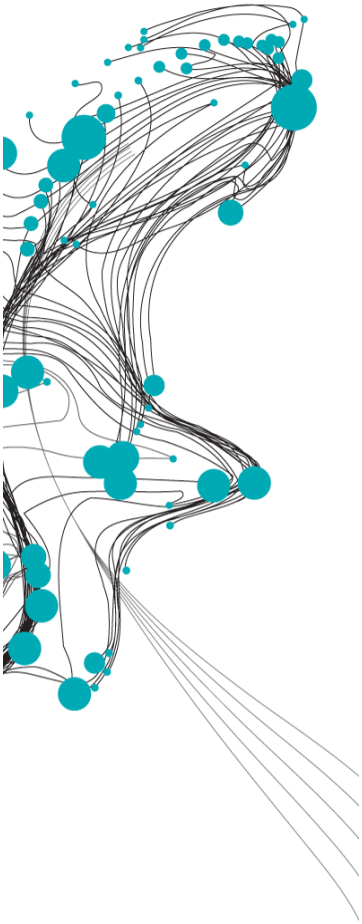
PIPING UNDER TRANSIENT CONDITIONS

INVESTIGATION OF TIME-DEPENDENT EROSION UNDER DIKES



Piping is the process of pipe formation in a sandy aquifer under river dikes. The current piping safety assessment of Sellmeijer (1988) in the Netherlands assumes that dike failure will occur when the difference between the water levels on both sides of the dike, the hydraulic head difference, exceeds a critical value. In reality, however, it takes time before the critical pipe length is reached. From then piping becomes irreversible (figure 1d progressive erosion) and the dike will collapse.

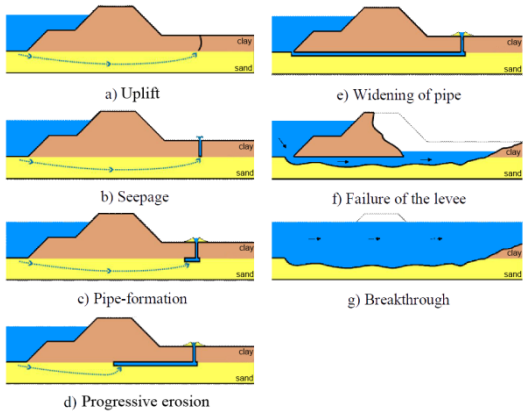


Figure 1 Steps in the process of piping.

Wang et al. (2014) derived formulae that can be used to determine the erosion velocity (pipe length increase per time step) under a constant head difference. It is, however, not clear what the effect of a variable head difference is on the erosion velocity. This Master's thesis project investigates the effect of piping under transient conditions by taking into account the time dependency of the piping process. A transient piping model (TPM) has been developed in which the existing theory of Sellmeijer (1988) is extended with an erosion velocity formula of Wang et al. (2014) to account for time and to simulate piping under a variable head difference. The TPM has been validated on three IJkdijk full-scale piping experiments.

The results show that a dike declared as unsafe by Sellmeijer (1988), does not always have to be unsafe to piping, when taking into account the time dependent aspect. This is an important finding as it might save money because dike strengthening is not needed in some cases. The more frequent a high water wave is expected to happen, the more likely it is that the TPM predicts no dike failure whereas Sellmeijer (1988) does. This conclusion, however, only holds for high water waves with a return period of more than 10 years. The chance of a different prediction by the TPM than by Sellmeijer (1988) is therefore the smallest for extreme high water waves.

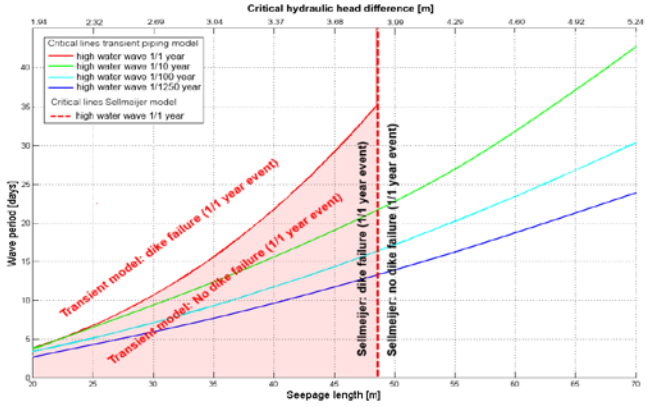


Figure 2 The time to progressive erosion for four high water waves for a dike nearby Tiel with aquifer thickness of 35 meter and aquifer permeability of 10 meter per day and an increasing seepage length. The area below the curves indicates no dike failure. The red area indicates a discrepancy in dike failure prediction (for a 1/1 year high water wave) by the TPM and the Sellmeijer model.

Sellmeijer, J.B., 1988. On the mechanism of piping under impervious structures, PhD Thesis. University of Technology, Delft.

Wang, D., Fu, X., Jie, Y., Dong. W., Hu. D., 2014. Simulation of pipe progression in a levee foundation with coupled seepage and and pipe flow domains. Journal of soils and foundations, pp. 100084, State Key Laboratory of Hydroscience and Engineering, Tsinghua University Beijing.

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