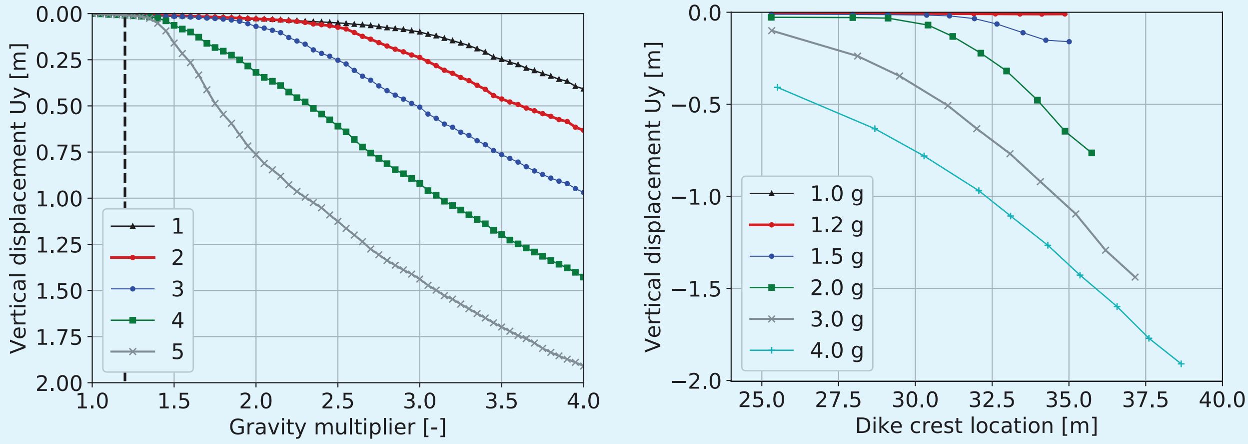
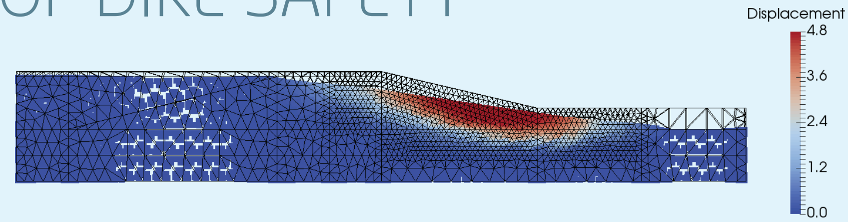


Dike deformation for different locations (left) and loading levels (right) on the crest

DEFORMATION-BASED ASSESSMENT OF DIKE SAFETY

Dike infrastructure plays a crucial role in the management of flood risks in low-lying areas near rivers and oceans. The material point method was adopted for dike macrostability analyses with the aim of making safety assessments based on deformation criteria and, given the fact that deformations at initial failure are often quite small, producing more economical designs.



Deformation (top) and shear strain (bottom) in the dike at maximum loading

Standard methodologies for assessments of dike macrostability are based on limit equilibrium methods (such as D-Geo Stability) that result in a factor of safety for shear failure. The more advanced alternative is the finite element method (an example being Plaxis) in combination with a strength reduction procedure. However, neither approach can take into account the actual capacity of the dike to retain high water levels since they consider only the mechanical equilibrium of the dike's initial configuration. In order to overcome this limitation, it was decided to adopt the material point method (MPM), which is available in the Anura3D software at Deltares and which considers the deformation of the dike body during failure.

On the basis of Anura3D MPM calculations, it was shown that, for the factor of safety corresponding to the limit equilibrium method, dike crest displacements are very small. This means that the factor of safety does not imply that the dike fails to retain water but only that an initial failure has taken place. After this initial failure, the dike slope stabilises in a new equilibrium position with an updated factor of safety. MPM allows us to look beyond this initial failure. In the case of the analysed dike, which was typical for Dutch conditions, we found that the dike continued deforming as the load on the dike increased and that the dike failure was progressive. Profiles for the dike crest deformation were computed that can be used to assess dike safety by combining deformation with criteria for the maximum allowed displacement of the dike crest.

Moving towards a displacement-based safety assessment of dikes has a positive impact on existing dikes by producing better predictions of their current safety level and on future dikes by making more economical designs possible. The results can be seen as a first step towards the assessment of dike macrostability on the basis of deformation criteria. Future work will focus on defining the maximum allowed crest displacement within the probabilistic framework of dike safety. The transition towards displacement criteria is likely to require more and different soil investigation approaches in order to determine the deformation parameters reliably.

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Further reading:

Zuada Coelho et al. (2018). Assessment of dike safety within the framework of large deformation analysis with the material point method. NUMGE2018, 25-27 June 2018, Porto, Portugal