John van Esch & Bert Sman

Modeling Groundwater Flow through Dikes and Levees

for Real Time Stability Assessment

Introduction

Climate change may alter future water levels and waves in rivers, lakes and seas. Delft-FEWS is designed for real time forecasting of these hydrodynamic conditions, using prediction models and monitoring data. This poster presents a new module: FEWS-DAM for real time stability assessment of dikes and safety assessment of entire flood defense systems by dynamic system simulation. The real time safety forecast is based on a large number of cross section stability analyses and associated time-dependent groundwater flow simulations.

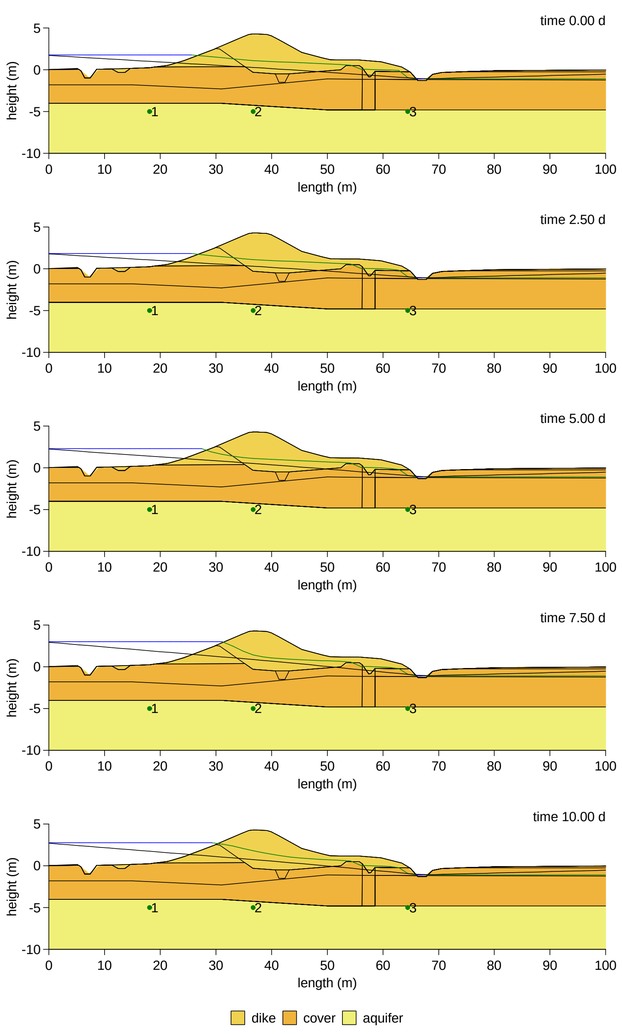

Figure 1: Dike cross section.

The groundwater flow model, which simulates flow through the aquifers and aquitards within the system and the embankment itself, is based on the Dupuit approximation. Special boundary conditions are added that capture the two-dimensional inflow of surface water into the dike, seepage of groundwater and the displacement of the low permeability cover layer due to excess pore water pressures.

Hydraulic forecast

The flood early warning system (FEWS) provides a real time forecast of the river water level by hydrodynamic model simulation, and returns an ensemble of 50 high water level scenarios.

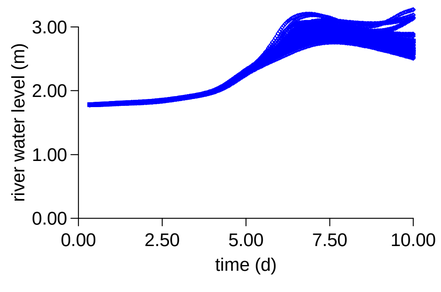

Figure 2: River water level forecast.

Geotechnical stability prediction

The dike analysis module (DAM) assesses the stability of the flood defense system by considering all hydraulic scenarios provided by FEWS. The groundwater module simulates time dependent pore pressure fields for each cross section separately. Bishop's method assesses slope stability and returns a factor of safety.

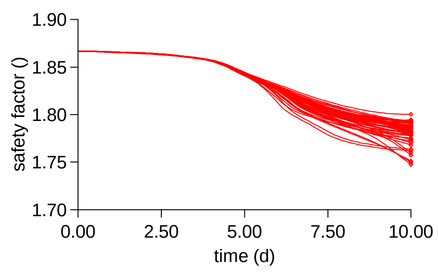

Figure 3: Stability prediction.

Hydraulic measurements

The flood early warning system assimilates hydraulic measurements and provides the dike analysis module with actual river water conditions along the flood defense systems.

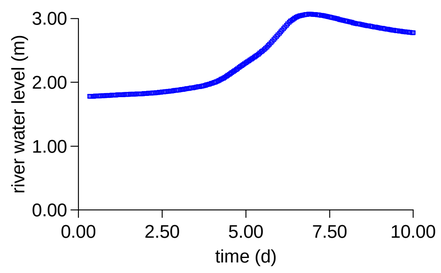

Figure 4: River water level measurements.

Geo-hydrological observations

Novel measurement techniques monitor the geo-hydrological system behavior and provide pore pressure data for calibrating the groundwater flow model. The Levenberg-Marquardt algorithm solves the inverse flow problem.

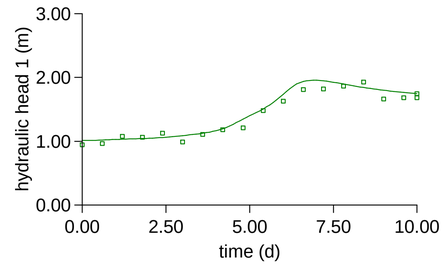

Figure 5: Hydraulic head measurements.

Conclusions

The groundwater module simulates groundwater flow through dikes and provides a computationally efficient procedure for predicting time dependent pore pressure fields. The water pressure fields support a slope stability analysis for dike cross sections, which are successfully used for real time stability assessment of entire flood defense systems. These results can be used to support timely decisions on preventive or remedial actions like the evacuation of people that live in the protected area or the use of retention polders, which reduces river level peaks.

Figure 6: Remedial actions.

Acknowledgement

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Deltares, Geo-engineering

John.vanEsch@deltares.nl