



Importance of rainfall events on levee stability

Stephan Rikkert and Matthijs Kok

Delft University of Technology, Civil Engineering and Geosciences, Netherlands

The Netherlands is protected against flooding by an extensive network of flood defences. As about 60% of the country is prone to flooding, failure of a flood defence has catastrophic consequences. Several failure mechanisms can cause the flood defence to fail. Our study focuses on macro-instability, which Kok et al. (2017) define as: “sliding of the landside slope, either due to water pressure exerted against the structure and increased pore pressure in the subsurface, or due to infiltration of the overflowing water when high water levels are combined with overtopping.” The pore pressure is time-dependent and occurs below the surface, which makes it hard to observe and predict. Therefore, pore pressures are a large source of uncertainty in levee stability analysis.

About 8.000 km of levees in the Netherlands are located along polder drainage canals. These canals discharge excess water from the polder to adjacent rivers or the sea. As a result of ongoing subsidence in these polders, the water level in the drainage canals is often above the surface level in the polders. The hydraulic head difference between the canal and the polder causes a continuous flow of groundwater through the levee, and a relatively high phreatic surface is always present. The water level in these polder drainage canals is controlled through pumps and sluices. This means that extreme canal water levels often coincide with extreme rainfall events. The response of the phreatic line in a levee to rainfall is hard to predict. Therefore, in flood safety assessments conservative estimates are made, in which rainfall is not explicitly taken into account. However, hydraulic head measurements, performed by local water authorities, showed that in some cases the measured phreatic line was above the conservative estimation, although the levee did not fail. Thus, how important is it to take rainfall explicitly into account in levee stability analysis?

In our study we demonstrate the importance of explicitly taking into account rainfall in levee stability analysis. First, we developed a relatively simple hydrological model to estimate the hydraulic head in a levee, based on rainfall and evaporation data. We calibrate the model parameters until a good fit with field measurements is realized and then use the model to predict the phreatic surface under extreme rainfall conditions. Finally, we performed a levee stability analysis, using the phreatic line predicted by the model. The results are then compared to levee stability analysis according to current practice.

Our results show that rainfall can have a large influence on the stability of a levee. Therefore, it is important to take effects of rainfall explicitly into account in levee stability analysis. Our proposed method makes it possible to take the effects of rainfall on the phreatic line in a levee explicitly into account. If evidence of survival of extreme rainfall events is available, our method can also be used to update the reliability of the levee.

Literature

Kok, M., Jongejan, R., Nieuwjaar, M., Tanczos, I. (2017). Fundamentals of Flood Protection. English Edition. ISBN/EAN: 978-90-8902-160-1