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Automated determination of flood risk through fragility

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Climate change causes an increase in flood risk due to higher water levels in rivers, seas and oceans. It is crucial to understand the effect of the changing water levels on the flood risk to properly manage the effects of climate changes. Practically all existing flood risk models assume a level at which an embankment will no longer preform its water retaining function and fail. In reality, the situation is much more complex. A flood protection embankment can breach many meters before the water reaches the top of the embankment, but it can sometimes also withstand higher water tables without breaching. This paper presents a scientific method for risk assessment and -management that properly takes the strength of the embankment into account. The paper focusses on the determination of the chance of failure of the embankment, given changing water conditions due to climate change. Examples show how this tool can efficiently be used for flood risk management.

Flood protection embankments can fail through many different failure mechanisms. The most obvious one is through insufficient height which causes overflow, erosion and finally breach. Other relevant failure mechanisms are, amongst others, macro instability, backwards internal erosion, suffusion and micro instability. The level at which an embankment overtops is easy to determine and therefor usually set equal to the level at which the embankment fails. Recent studies in the Netherlands show, however, that the other failure mechanisms are often dominant, depending on the subsoil conditions. Ignoring these mechanisms give a far too optimistic risk assessment and therefore, these mechanisms must be taken into account.

This paper shows an automated methodology to properly represent the strength of flood protection embankments through fragility. A fragility curve is a graph in which the chance of failure of the embankment is plotted against the water level in the river. This database driven methodology uses GIS data to make a representation of the embankment and automatically determines the chances of failure for every relevant failure mechanism at every river water level. When the source database is updated, the fragility curve for the embankment can directly be updated as well to easily adapt to changes. Multiplying this fragility curve with the probability density function of the outside water level directly results in the chance of failure of the flood protection embankment. Scenario studies for different climate changes can easily be performed and be presented in a clear, visual way to the decision maker.