Storyline

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Storyline

Proof loading and monitoring to optimise flood defence asset management

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Estimates of the failure probabilities of flood defences are influenced by many different uncertainties. Uncertainties about, for example, the strength of the subsoil or the response of the water pressures to high water, often lead to improvement of flood defences with large stability berms.

Although reducing those uncertainties always sounds very promising, application is often difficult in practice and does not always lead to the expected or desired result. For example, if pore pressures are only measured for a short period of time, the probability of a relevant high water passing by during that period is rather small. 'Other' uncertainties may also suddenly appear, which were not yet in sight when monitoring was started. However, these can have a major influence on the probability of failure. Consider, for example, the water pressures in the dike body, while the measurement campaign focused only on the water pressures in the aquifer. Then you have learned something, but not the information that is really needed.

"If only we'd have known that..."

In recent months, we have been working on a method to consider in advance whether and which uncertainty reduction method will lead to the highest expected profit. We explain it below.

Cover photo: Proof loading by infiltration of the Hollandse IJsseldijk. Photo by Michiel van der Ruyt.

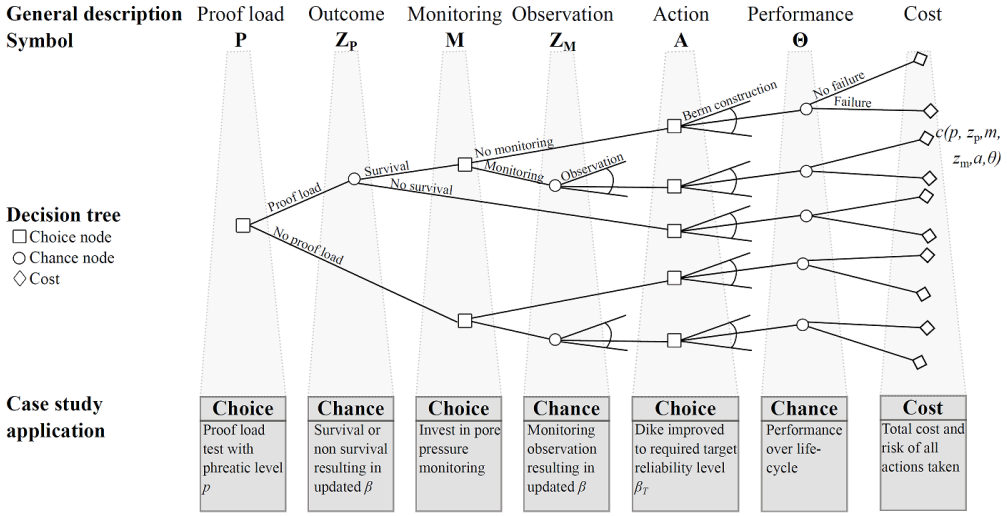

Figure 1: Decision tree for flood defence asset management. Source: van der Krogt et al. (2020, Figure 1).

Influential factors	Positive impact	Remark
Proof load level	Higher proof load, more uncertainty reduction.	The increased risk of failure does not always outweigh the potential benefits, especially if consequential damage is high.
Larger geotechnical uncertainty	Proof loading is more effective	Pore pressure monitoring might become attractive only after reducing geotechnical uncertainty. It is recommended to determine the sequence of measures based on their relative uncertainty contribution and consider other methods (e.g., site investigation).
Higher construction cost of stability berms	Uncertainty reduction methods are more attractive as the benefits are larger.	Other methods for reinforcement might be more effective.

Table 1: specific factors that play a role in the decision to monitor pore pressures or to apply a proof load test. Source: van der Krogt et al. (2020, Table 4).

In the average of 5 years typically available between rejection (i.e., we do not meet the required safety level anymore) and reinforcement of a dike, valuable time is available for additional research. We consider two ways:

1. Doing a proof load test by artificially raising the phreatic level
2. Monitoring of pore pressures to improve insight in the response of the phreatic line to high water levels.

In our method, we calculate the value of the extra information that we expect as a result of proof load tests and monitoring. The additional information improves failure probability estimates for slope stability. In most cases, just the uncertainty reduction is not sufficient to meet the failure probability, but a much smaller berm can be constructed. Bottom line, the extra information leads on average to a lower flood risk and cheaper dike improvements.

We compare the costs and benefits of various combinations of proof load testing and monitoring with the 'basic strategy' of simply constructing a stability berm. We also include the possible additional costs such as the risk of damage in the event of a failed test load. We call the lower costs compared to 'doing nothing' the Value of Information, or VoI. A positive VoI therefore indicates that a strategy is on average a good choice.

The calculations show which factors and conditions determine whether an asset manager should monitor pore pressures or opt for proof loading. A very clear outcome is that it is very important to focus the uncertainty reduction on the uncertainties that are most dominant for the failure probability. A probabilistic analysis provides valuable clues to determine which those are.

"Focus on the uncertainties that are most dominant for the probability of failure"

Other specific factors that play a role in the decision to monitor pore pressures or to apply a proof load test are listed in table 1.

The results show that it is essential to carefully consider how and which uncertainties can be reduced in order to achieve efficient management of flood defences. And it can be slightly different for each flood defence.

Interested to read more?
Click or scan the QR Code to view the online version of this storyline.

Are you curious about which additional factors and circumstances are decisive for the decision to monitor water pressures or to test loads? Read it for yourself in our article:

van der Krogt, M.G., Klerk, W.J., Kanning, W., Schweckendik, T., Kok, M. (2020). Value of information of combinations of proof loading and pore pressure monitoring for flood defences. *Structure and Infrastructure Engineering*. Doi: 10.1080/15732479.2020.1857794

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