Safety assessment of multifunctional flood defences

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Multifunctional flood defences (MFD) are being implemented all over the world and still they are being designed upon risk based international codes that specify unique partial safety factors despite the fact of load variability (Vrijling, Schweckendiek et al. 2011). One of the main challenges for the implementation of MFDs is to develop tools for including them in the current safety philosophy and flood safety assessment guidelines for the Netherlands. There is a lack of knowledge on their safety assessment procedures as their failure mechanisms may differ in their probability of occurrence compared to a conventional flood defense structure due to the additional required functions of the MFDs. Nowadays, these kind of structures are being conceived as potential urban habitable areas (**Figure** 1) and therefore they need to be assessed from scratch in safety terms that consider climate change land use variability.

Fig. 1 *Tokyo and Osaka flood defence improvement project (Japan Times, October 2010)*

Objective

The main objective of this research is to establish how the different failure mechanisms will change their probability of occurrence given their main design parameters such as geometry, construction materials and estimated loads. Once the most probable failure mechanisms are identified given a certain parameter, a set of design safety factors (load multipliers) is going to be calculated based on their conditional probability in a reliability analysis.

Methodology

The first part of the study consists on predicting the uncertainty of the main design parameters. Then the propagation on the reliability functions of the failure mechanisms. In order to achieve this Stochastic uncertainty analysis is used to generate large data samples. These samples are going to be classified with a Bayesian Network method in order to generate a dynamic fault tree based in their conditional probability of occurrence. This method will also give the opportunity to identify which failure mechanisms may influence the occurrence of other mechanisms based on the assumptions of their dependence (Aguilera, Fernández et al. 2011).

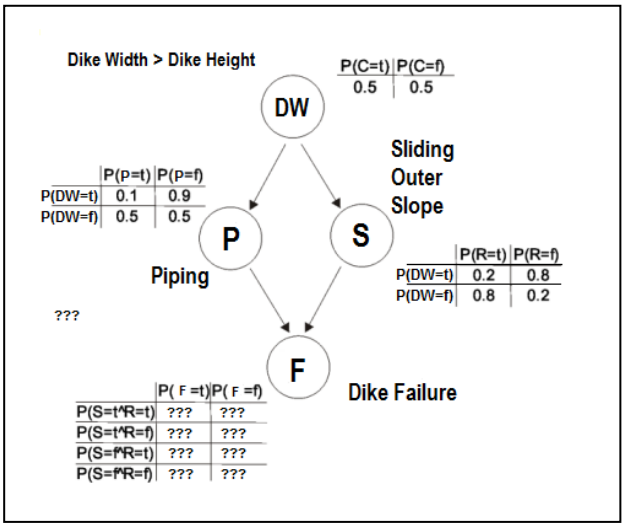

Figure 2 *Bayesian Network for dike Failure*

After being able to predict the sequence of importance of the failure mechanisms, the second part of the research consists of

producing a deterministic design set of safety factors based on probabilistic generated results. These probabilistic results are produced by building several models that can simulate different failure mechanisms at the same time. The results of this models are going to be used to build statistical distributions of the design parameters which can help later to estimate the influence of the design criteria in the structure reliability (Ramu, Kim et al. 2010) of the defences. They also will help validate the actual reliability equations for MFFD's. If the parameter's uncertainty is better understood, this will be traduced in a more optimal design criteria of selecting the partial safety factors which can be used to reduce the failure probability (Failure red area **Figure 3**). By reducing this area, the estimated Safety Factor required for a particular failure mechanism will be more robust and less uncertain.

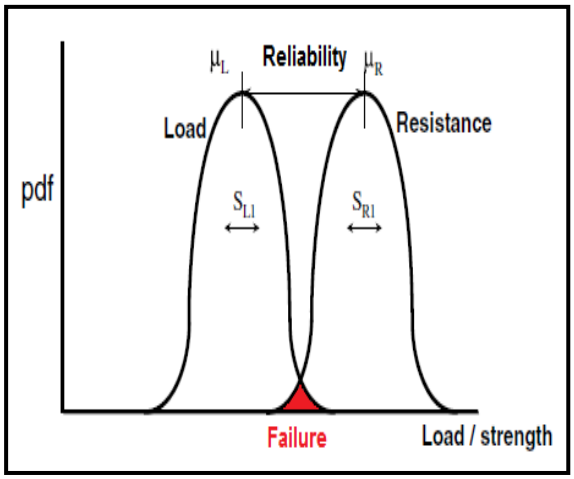

Figure 3 *Failure estimation from load and resistance statistical distribution*Expected results

If a better understanding of the parameters of design and their influence in the failure probability is possible to be described then (Ching 2009), the gap between deterministic (Safety Factors) and Stochastic (Reliability) can be narrowed as the reliability of the structure becomes more certain (**Fig 4**). Despite the fact of the randomness of nature (soil parameters, water levels and wave heights) there are some other parameters like the geometry, death loads and constructive materials properties that if well understood, they might improve the estimated response capacity of the structure in case of a flooding event.

Expected results

At the final stage of the study it is intended to produce a tool that assesses designers and managers of these future structures how to select the required safety factors for the most probable failure mechanisms, that considers also the associated probability of failure and the uncertainty of the design parameters.

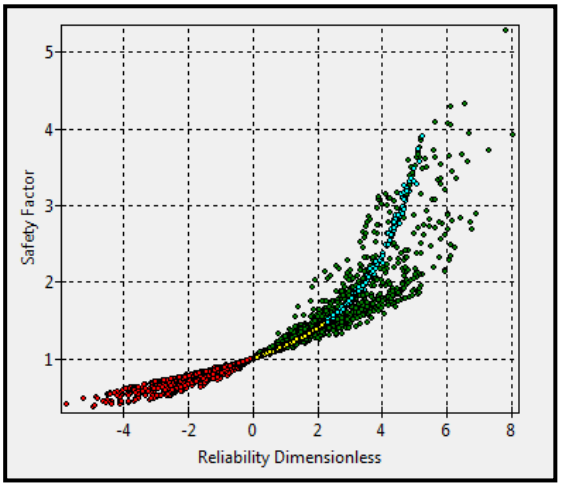

Fig 4 *Reliability Vs. Safety Fact*

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