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How does the risk-based approach work?

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The Dutch risk-based safety standards

The Dutch risk-based approach to safety standards of flood defences dates back to the 1950s where Van Dantzig and others derived optimal protection levels for the main dike ring in the west of the Netherlands. Practically though, this optimal level of protection was translated to a design water level with an annual exceedance frequency of 1/10,000. The flood defences are designed in such a way that they survive the design water level, and this method is called the overloading approach. Later, this overload approach was translated to standards for areas with lesser consequences.

From 2017, after 20 years of study and consideration, new safety standards have been implemented. In contrast with the previous overload approach, the new standards are supposed to reflect actual failure probability and are based on various consequences. Flood defence segments are assigned to safety standards, defined as maximum allowable failure probability, where the standard (varying between 1/300 and 1/100,000 per year) depends on the consequences in the area and are based on the economic value these protect, individual risk and group risk. The *Beoordelings- en Ontwerp Instrumentarium (BOI)* – Assessment and Design Instrument – (Rijkswaterstaat, 2019) translates these safety standards into requirements for individual flood defences and failure mechanisms in such a way that if the defences comply with these requirements, the safety standards are fulfilled.

Efficient flood risk reduction

The probabilistic flood approach has several advantages. First, the new approach reflects the actual risk (probability and consequence) and facilitates efficient investments. The corresponding maximum allowable failure probabilities are relatively easy to communicate. Further, it is a flexible framework where uncertainties are explicitly incorporated. The consideration of uncertainties allows a more transparent safety assessment and design of both traditional failure mechanisms and innovative measures. Different measures such as strengthening, monitoring and measurements can be transparently evaluated using the risk approach. The flood probability approach is suitable for combining different types of knowledge, including physical knowledge about hydraulics and geotechnics, the behaviour of dikes, as well as the knowledge of statistics and uncertainties. For example, uncertainties arising from the available information and quality of models are included, as is shown in Matthijs Gensen's research on the uncertainties around the

bifurcation points. The allowable failure probabilities connect well to the EuroCode definitions and provide a clear basis for the flood defences' design and assessments. Moreover, this flood probability approach allows including the actual failure (a dike breach) rather than only the initiating mechanisms, for instance, by incorporating that a slope stability does not necessarily result in a breach. All these improved considerations of the flood probability approach should result in more efficient investments in flood defences.

A recipe or a framework for decision making?

The flood probability approach provides clear advantages, but current implementation and results also highlight challenges to overcome. There is still conservatism in the BOI and especially in choices in the failure mechanism modelling, leading to very high reported failure probabilities, much higher than recent experience suggests. Also, it can be questioned whether the BOI is too much applied as a recipe; does it sufficiently stimulate critical thinking? There is a lot of emphasis on making many computations, but is there enough room for critical thinking, detailed analysis, measurements, technical managers' experience, monitoring and other uncertainty reduction? Dikes fail because of missed layers, missed connections between outside water and aquifer etc. This should be a main point of attention in design and assessment. The flood risk approach provides incentives for uncertainty reduction, but this should be much more applied, as was underscored by the expertise network for water safety (ENW, 2020) as well. The flood risk approach allows for optimal investment in time and space. This new approach can result in many optimisations as All-Risk research has shown. Practical application of this is, however, very limited. Also, inspection and maintenance should be an integral part of assessment and design, which is currently not the case as we tend to model a perfect reality that hardly exists, as this book shows. Most of the above may be attributed to the relatively short time the flood risk approach is being used.

Towards better water safety in the Netherlands

The new flood risk approach provides an efficient, transparent and flexible framework with clear safety standards to make efficient flood risk reduction investments. It has already proven its value in many projects. After an initial period of adjustment to get the old way of assessment and design adjusted to the new approach, it is now time to fully reap the benefits of the new approach. All-Risk has provided knowledge and tools to facilitate this. We hope and expect that more and more benefits will be applied in practice in the years to come.

Figure 1: Soil drilling for analysis of the layers of a dike body. Photo by HWBP.