Performance and reliability of flood and coastal defences

Technical Summary FD2318

Joint Defra / EA Flood and Coastal Erosion Risk Management R&D programme

Background to R&D project

A key factor in assessing flood and erosion risk is understanding the reliability of defence structures. Risk is a combination of probability and consequences. Structures with a high probability of failure tend to result in a high risk. With the move from 'flood defence' to 'flood risk management', it is important to understand the probability of failure from imposed loads both above and below a nominal level, such as a crest level.

There are a number of ways of deriving and presenting this information, one of which is the use of 'fragility curves', which are a convenient way to capture and summarise information about the performance of an engineering system. Fragility curves were found very useful with the RASP (Risk Assessment for Strategic Planning) approach to modelling flood risk, but required more research to provide a stronger scientific basis. This project was commissioned to address this with the following objectives:

- To explore the available approaches to characterising the reliability of flood and coastal defences.
- To develop scientifically-based 'fragility curves'.
- To provide clear guidance on developing and using fragility curves for reliability analysis of linear raised defences such as embankments and walls

Results of the R&D project

Failure processes and physical process based models

The project investigated the failure modes of a wide range of flood and coastal defence types in a literature review and desk study, including interviews with practitioners to capture their experience, resulting in an inventory of the main failure mechanisms and the most appropriate physical process-based models for each, together with their data requirements. The choice of process-based model and number of failure modes should be tailored to the tier of decision-making and data availability in that tier.

Process-based models are in most cases available but with varying degrees of complexity. Although much research has already been done, further development and validation is required. There also needs to be further development of the understanding of deterioration processes and related process-based models.

Applicability of fragility curves

An investigation of reliability analysis methods in other countries (mainly the Netherlands, Germany and USA) and other industries (nuclear, seismic and mechanical engineering) found that process-based structural reliability analysis is well established and fragility curves are suitable for summarising results for many, but not all, types of failure. The quality of the fragility results hinges on the quality of:

- the underpinning process-based models
- the representation of the uncertainties in those models and data
- the data availability
- the accuracy of the chosen calculation methods.

Developing and using fragility curves

The steps to create fragility for a dominant failure mode, as well as the data requirements, are given in TR 1. The methodology used to construct fragility curves for the main defence types in the annexes of TR1 is given in TR 2.

This captures the indicative failure modes in more detail and is used to construct the 'default' or generic fragility curves for the main defence types. These default or generic curves include some simplifications - they could be refined when moving towards more detailed structure-specific assessments.

R&D Outputs and their Use

The project has produced two main complementary outputs. Volume one (FD2318/TR1) describes the background and basis of fragility curves and their application. It gives a step-by-step guide to constructing them, along with useful guidance on reliability analysis. Importantly it includes a full set of fragility curves for each of about 60 defence types, covering all five Condition Grades, and some include upper and lower bounds to indicate the degree of uncertainty. Volume two (FD2318/TR2) provides more in-depth technical treatment including the reliability functions that have been used. Both TR reports are presented in a fairly high level of detail and will be of value to a wide range of users for assessing and managing risks, the development of further models and tools, as well as those requiring in-depth treatment of the subject.

A separate Project Record includes more detailed reports and source documents including a literature review, a review of flood and coastal defence failure and failure mechanisms, and a review of the applicability of fragility curves. It also contains workshop presentations and a summary of spreadsheet software developed to demonstrate sensitivity of fragility curves to changes in input parameters.

This R&D Technical Summary relates to R&D Project FD2318 and the following R&D outputs:

- **R&D Technical Report FD2318/TR1 – Performance and reliability of flood and coastal defences Volume 1.** Published November 2005.
- **R&D Technical Report FD2318/TR2 – Performance and reliability of flood and coastal defences Volume 2.** Published November 2005.

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The above outputs may be downloaded from the Defra/EA Joint R&D FCERM Programme website (www.defra.gov.uk/environ/fcd/research). Copies are also available via the Environment Agency's science publications catalogue (http://publications.environment-agency.gov.uk/epages/eapublications.storefront) on a print-on-demand basis.

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