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Reliability Analysis of Coastal Flood Defences under Extreme Storm Surges

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Introduction

In the past, storm surges have frequently led to failure of coastal flood defences which caused major damages, also along the German coastline. Due to climate change and increasing intensities of storm surges (IPCC, 2007), it may be expected that the risk of flooding will significantly increase. In order to enhance the knowledge in extreme storm surge predictions and in the assessment of the related risk the German joint research project XtremRisK was initiated (Oumeraci et al., 2009). The general aim of the project is to quantify the overall flood risk under present and future climate change conditions for an open coast (Island of Sylt, North Sea) and an estuarine urban area (Hamburg, Germany). In the XtremRisK project an integrated risk analysis approach (Oumeraci, 2004; Burzel et al., 2010) is used wherein one of the major tasks is the determination of the failure probability of coastal flood defences.

Flood risk is defined as the product of probability and related consequences. Hence, one task is to predict the first component of the flood risk, i.e. the probability of the hinterland being flooded. Therefore, using different extreme storm surge scenarios the loading and the stability of all components of the flood defence systems are determined and a reliability analysis with the overall failure probability as the ultimate result is carried out. This paper will discuss the first results of the overall failure probabilities of the flood defences in Hamburg and Sylt using updated or new methods and data.

Methods and Results

Using a probabilistic approach considering the uncertainties of the input parameters, a reliability analysis for flood defences is carried out (Naulin et al., 2010). Therefore, characteristic subareas of pilot sites for the Island of Sylt and the Elbe estuarine area of Hamburg were selected. The flood defence line of these subareas was divided in sections with similar characteristics such as type of structure, geometric and geotechnical parameters.

For these sections, all input parameters and their uncertainties were investigated. Moreover, for this purpose, the limit state equations comparing strength and loading of the assets for all failure mechanisms of the flood defence structures are examined based on the results of previous projects such as ProDeich (Kortenhaus, 2003) and FLOODsite (Allsop et al., 2006). The knowledge gaps are identified and closed, e.g. by developing missing limit state equations and fault trees for structures not yet considered.

First, the failure probabilities are determined by a calculation for each section using a fault tree analysis combining all failure modes for each flood defence component. From this, the overall failure probability for the coastal flood defence system for each subarea is calculated using a fault tree approach. The methods for the reliability analysis including software tools such as the FLOODsite software tool RELIABLE (Van Gelder et al., 2008) or Palisade @RISK under MS Excel will be developed further regarding the new limit state equations and fault trees. These updated and new methods with first results of the reliability analysis of coastal flood defences will be presented at the conference.

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