2023_22_DCEE_O'Sullivan: Improving the resilience of UK flood protection infrastructure using advanced numerical simulation

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The UK has 9,000 km of flood embankments and 2,072 dams retaining large raised reservoirs. These large geostructures perform a crucial role to prevent flooding which can have significant societal and environmental impact. Climate change is increasing the demand on these structures. The UK Environment Agency (EA) estimates an increase in peak river flow in UK rivers by at least 10% from 2020-2039; greater increases are anticipated up to 2115. UK sea levels will be about 1 m above 1990 levels by 2115. These changes will significantly increase the risk of embankment collapse or breach. This project will exploit advanced numerical simulation tools, developed to look at scour around pipelines to better understand how to protect these structures against erosion during flood events.

Different mechanisms may initiate erosion (head-cut erosion, surface erosion, or internal erosion). However, whatever the initiating mechanism, the soil erodibility determines the subsequent rate of erosion. The various models used to predict breach all rely on a measure of soil erodibility. A recent scoping study by the EA (UK Environment Agency) concluded that there is incomplete understanding of soil erodibility, how to measure it, and how to consider the inherent heterogeneity of embankment materials. This doctoral research project aims to improve measurement of soil erodibility in the UK by simulating the tests used to assess soil erodibility using advanced multi-phased, coupled numerical models.

The research will comprise two main phases (1) an assessment of how erodibility is measured (2) understanding the erodibility of key UK soils.

(1) How do we simulate soil erosion under flood conditions (Months 1 – 24)

To develop an in-depth understanding of erosion this numerical phase of the research will focus on simulating the various tests that have been proposed to measure soil erodibility. This will allow the existing modelling tools to be adapted to this application.

(2) What are the mechanics of erosion? (Months 24 – 38)

This phase of the research will focus on developing the insight obtained in the modelling work to engineering application. The insight gained through these simulations in phase 1 will help designers assess how to incorporate the test data in breach prediction models which are essential to understand the potential large-scale implications of erosion. The key question to answer: is when is there surface erosion versus a head cut erosion?

(3) Thesis write-up (Months 39-42).

Dr. Mark Morris from HR Wallingford who worked on the EAs scoping study, along with Dr Mohamed Hassan (also from HR Wallingford) will act as external supervisors. The research will link into complementary ongoing research led by EDF and CNR, which also aligns with earlier work and interests of the US Army Corps of Engineers and Bureau of Reclamation.

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