Piping erosion of earth dams: a review of related issues and existing models

Supervision team

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This Master degree internship will be dedicated to the micromechanical modeling of the piping erosion mechanism in earth dams. This will be part of a collaborative project involving EDF CIH (Bourget-du-Lac, France), INRAE (RECOVER, Aix-en-Provence, France), and University Savoie Mont Blanc (Lab ISTerre, Bourget-du-Lac, France). In this respect, it will benefit from a multidisciplinary and dynamic environment.

Context and motivations

Many hydraulic structures such as dams or dikes are made of porous geomaterials. As a result, they are subjected to infiltration flows, which may lead to the development of internal erosion. The latter is divided into four initiation mechanisms, namely backward erosion piping, contact erosion, concentrated leak erosion and suffusion. The continuation and progression of these mechanisms can open up a pipe in the structure or its foundation, resulting in piping flow erosion. This is the most dangerous scenario since it can lead to the complete failure of the dam or the dike within few hours, with very limited possible actions to control the process once initiated.

To assess the impact of a failure, it is necessary to predict the breach hydrograph (i.e. the flow rate through the breach as a function of time) consecutive to piping flow erosion. However, no numerical model yet exists to describe the full physical processes from the initiation of the concentrated leak process to the piping roof collapse and the breach widening in a deterministic manner with a proper validation on experimental data from large-scale tests or data from actual breach cases. Breach hydrographs are currently determined from very simplified approaches based on empirical formulas, which present large uncertainties without guaranteeing always-conservative results. In particular, breaches open quicker consequently to internal erosion (the scenario described above), compared with overflowing.

Prior to developing a deterministic numerical modeling representing the full physical processes occurring during a dam or dyke failure by piping erosion, an intermediate objective is to develop a deterministic numerical modeling of the Hole Erosion Test (HET). The HET is a laboratory experiment which reproduces the piping process in a soil sample and provides the erosion parameters I_e (Erosion Index) and τ_c (critical stress) characterizing the soil erosion resistance.

Objectives

This Master degree internship is intended as a first qualification before moving towards a PhD thesis devoted to the numerical modeling of the Hole Erosion Test. The proposed Master degree internship will have an intermediate, but nonetheless essential, objective to perform a thorough state-of-the-art review in the field of internal erosion piping processes, including both numerical and experimental contributions and remaining open issues. In particular, a comparative study of coupled fluid/granular

medium numerical methods is expected in terms of method reliability and efficiency, computational cost and accessible spatial scales as well. Then, the definition of 3D fluid/grains simulations will be envisioned to simulate the local erosion process in the form of grain detachment in a discrete element method (DEM) software.

Perspectives

According to the outcomes achieved at the end of the internship, a PhD thesis grant will be offered to the applicant to pursue this research work as a PhD candidate.

Application

We are looking for a candidate having numerical simulation skills, preferably with hydraulics and civil engineering background. Inquiries and applications should be sent by email to the following addresses:

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Terms and contract

The candidate will be hosted at INRAE in Aix-en-Provence, France. Short-term stays at EDF-CIH in Chambéry will be planned. Regular meetings with all the partners will be organized along the whole duration of the internship.

The internship is scheduled to start in March/April 2023 (with some flexibility) for a period of 6 months.

The traineeship grant is expected to be around 600 €/month.