Thesis proposal

Soil surface erosion: local law and influence of soil and flow properties on the erosion resistance of hydraulic structures

Host Laboratories :

UMR RECOVER, Irstea, Aix Marseille Univ, Equipe G^{2}DR, Aix-en-Provence
Université Paris Est, ESTP Paris, Institut de Recherche en Constructibilité, Cachan, France

Context: Erosion in earthen hydraulic structures such as dams and dikes is a major source of safety concerns. Indeed, erosion can be at the origin of instabilities and failures of these earthworks structures which can lead to disastrous consequences on the socio-economic level, causing material losses in the hundreds of thousands of euros and, in the most dramatic cases, loss of life.
The susceptibility of hydraulic earthworks to surface erosion depends on many parameters related to the soils properties (type of soil, GSD, particle size and shape, porosity, texture, dispersivity, etc.) and hydraulic flow (flow velocity, hydraulic gradient, pressure, etc.) which have an influence on erosion phenomena.

This thesis, proposed as part of a scientific collaboration between ESTP Paris and Irstea Aix-en-Provence, has for main objective the contribution to the fundamental understanding of the sensitivity of soils to interface erosion in order to improve the risk management for earthworks.

Objectives and methodology: The research activity that will be carried out during this thesis aims to better characterize the sensitivity of soil to interface erosion according to the physico-chemical and geotechnical parameters of soils and, in particular, to develop methods of interpretation that will lead to an objective classification of soil sensitivity to interface erosion, irrespective of the experimental devices used. A more general objective is to increase the safety of hydraulic earthworks to provide greater resilience during periods of floods, storms and other meteorological or technological hazards by making recommendations for improvements in design, sizing and construction methods of structures (dikes, dams) or their foundation (bridge piers, etc.).

This study will focus in particular on the surface erosion of geomaterials to determine (i) the initiation conditions of erosion process, and (ii) erosion kinetics under stationary or near-stationary conditions. The investigation is based on an experimental approach that gives separately access to the erosion rate and the shear stress at the soil-fluid interface. To determine the erosion characteristics, i.e. the erosion threshold (or critical stress) and the kinetics of erosion, and study the influence of different parameters on the process, two experimental devices will be mainly used: HET (Hole Erosion Test) and EFA (Erosion Function Apparatus). In both cases, these devices consider a flow in charge along a pipe. The difference between them is the soil/water contact surface's geometry as well as the hydraulic radius of the flow. Additional tests with the JET (Jet Erosion Test) device may be considered on an "impinging jet" type configuration with a very different hydrodynamic loading, which will make it possible to test the influence of load on the same soil sample.

Furthermore, the present thesis aims to answer a number of questions in order to properly model surface erosion. A relevant erosion law will be developed linking together the erosion parameters. The challenge is to assess whether there is a single local law capable of describing surface erosion of a soil under various hydrodynamic conditions (such as those of the EFA, HET, or JET) and, if required, to propose improvements of the local law, even to formulate alternative laws by seeking the best coherence between the various test devices results. Then, it will be assessed to what extent the physical properties of the soil are related to the parameters of the proposed erosion law. The chosen methodology will consist of testing model and artificial materials, taking into account the feasibility of the tests in both test configurations. Particular attention will be given, on the one hand, to the choice of soil constitutive parameters likely to play a significant role in the surface erosion process, and, on the other hand, to the test protocols.

Modalities: The thesis will be carried out successively at the Irstea center of Aix-en-Provence (18 months) and ESTP Paris (18 months). The contract will start preferentially on October 1st, 2019.

Candidate profile: The candidate must have a good knowledge in at least one of the two geotechnical/geomechanical and fluid mechanics specialties, and a strong attraction for experimental research. In geotechnical engineering, the candidate will have to consolidate or acquire skills in terms of soil characterization (density, GSD, permeability, water content, Atterberg limit, etc.) with the classical tools used in geomechanics. In fluid mechanics, the candidate will have to consolidate or acquire experimental skills in laser velocimetry and theoretical knowledge on the boundary layer and turbulence.

The candidate must hold a Master 2 degree at the end of the current year in one of the mentioned specialties.

The deadline for applications is 15 June 2019.

Applications should be sent to apoupardin@estp-paris.eu and nadia.benahmed@irstea.fr