Research Master Internship

Subject: Internal erosion within hydraulic earth structures and eroded soil behavior subjected to complex hydro-mechanical loadings

Context: Research partnership between EDF-CIH, Verbund and the GeM Institut (UMR CNRS 6183)

Starting date: February 2020
Funding length: 6 months

Scientific supervisor:
Didier MAROT, Professor
Tel: 0033 + 2 72 64 87 32 – 0033 +2 40 17 81 91
Email: didier.marot@univ-nantes.fr

Localization:
GeM Institute (UMR CNRS 6183)
Université de Nantes
58 rue Michel Ange
44600 Saint-Nazaire
https://gem.ec-nantes.fr/ieg-2/

Research topic:
Hydraulic earth structures such as dams or dikes ensure several important functions: retain or transport water for hydroelectric purposes and irrigation, protection against flooding and overtopping. In the world, numerous failures of these structures have been reported which have serious human, economics and material consequences. Internal erosion is the leading cause of failure within hydraulic earth structures [1]. When water flows through these structures, some particles that are part of the solid skeleton are being pulled of and transported by the hydrodynamic forces of the seepage flow.
This phenomenon leads to the aging of the hydraulic earth structure, which implies a diminution of its water-tightness capacity and mechanical resistance. The development of this phenomenon can trigger the failure of the structure. According to the statistics compiled by Foster et al. [2] regarding large dams, 94% of these failures are caused by erosion. In addition, the failure risk relative to erosion increases with time. Finally, the intergovernmental panel on climate change points toward an increase in frequency and intensity of local rainfalls and therefore of the hydraulic loading on these structures. As a consequence, the failure risk is increased. Hence, the security level of hydraulic earth structures needs to be assed in an objective manner to optimize their maintenance.

Research on this problematic has the ambition to answers the needs of hydraulic earth structures stakeholders.

Various experimental testing programs have so far focused on the characterization of the suffusion susceptibility of soils towards internal erosion, and in particular suffusion [3, 4, 5]. Following this objective, several experimental apparatuses such as the œdopermeameter and two triaxial erodimeters were developed to test in laboratory controlled conditions a large range of materials from fine to coarse [4]. Thanks to these programs, an energy approach was proposed to characterize in a robust manner the suffusion susceptibility of soils [6, 7, 8, 9].

In this context, the internship student will study the bibliography of internal erosion and of the mechanical behavior of eroded soils [10].

The second task will consist in characterizing the mechanical behavior of eroded specimens subjected to mechanical states that are representative of in-situ conditions.

In the end, we wish to highlight that this research is undertaken in the framework of a larger scientific collaboration that comprise another industrial partner and a northern American university.

Perspectives:
At the end of this internship, the research partnership will hire a Ph.D. student to pursue this research project. The funding for this Ph.D. thesis is already secured.

References:

[1] Fry, J. J., Vogel, A., Royet, P., and Courivaud, J. R., Dam failures by erosion: Lessons from ERINOH data bases. *Proc., 6th Int. Conf. On Scour and Erosion*, Paris, 273 – 280, 2012.
[2] Foster, M., Fell, R., Spannagle, M., The statistics of embankment dam failures and accidents. *Can. Geotech. J.*, vol. 37, 1000-1024, 2000.
[3] Bendahmane F., Marot D., Alexis A., Experimental parametric study of suffusion and backward erosion. *J. Geotech. Geoenviron. Eng.*, 134(1), 57-67, 2008.
[4] Sail Y., Marot, D., Sibille, L., Alexis, A., Suffusion tests on cohesionless granular matter. *Euro. J. Environ. Civ. Eng.*, vol. 15, 2011.
[5] Rochim A., Marot D., Sibille L., Le V.T., Effect of hydraulic loading history on the characterization of suffusion susceptibility of cohesionless soils. *J. Geotech. Geoenviron. Eng.,* 143(7), 2017.
[6] Le, V. T., Marot, D., Rochim, A., Bendahmane, F., & Nguyen, H. H., Suffusion susceptibility investigation by energy-based method and statistical analysis. *Can. Geotech. J.,* 55(1), 57-68, 2017.
[7] Zhong C., Le V.T., Bendahmane F., Marot D., Yin Z.Y., Investigation of spatial scale effects on suffusion susceptibility. *J. Geotech. Geoenviron. Eng.,* 144(9): 04018067, 2018.
[8] Sibille, L., Marot, D., Sail, Y., A description of internal erosion by suffusion and induced settlements on cohesionless granular matter. *Acta Geotechnica,* 10(6), 735-748, 2015.
[9] Zhang, L., Gelet, R., Marot, D., Smith, M., Konrad, J. M., A method to assess the suffusion susceptibility of low permeability core soils in compacted dams based on construction data. *Euro. J. Environ. Civ. Eng.*, 1-19, 2018.
[10] Rousseau, Quentin, et al. "Constitutive Modeling of a Suffusive Soil with Porosity-Dependent Plasticity." European Working Group on Internal Erosion. Springer, Cham, 2018.

Keywords: Soil mechanics, hydraulic, cohesionless soils, experimentation tests, internal erosion, mechanical behavior

Required skills: Taste for experimentation and team work, soil hydraulics, soil mechanics, continuum mechanics, constitutive laws, bases of geotechnics

Interested candidates are encouraged to apply by sending:
- a CV with a list of up to 3 references,
- a transcript of the school grades,
- a short statement (maximum of one page) describing past experience and research interests.