Demi-journée thématique et séminaire de la Fédération GE@2M

Jeudi 07 décembre 2023

14h00-16h00

Pierre-Yves HICHER
GeM UMR CNRS 6183
Professeur Honoraire à l'École Centrale de Nantes

&

François NICOT
ISTerre UMR CNRS 5275
Professeur des Universités à l'Université Savoie Mont-Blanc

Organisé par

Laboratoire d'Étude des Microstructures et de Mécanique des Matériaux
LEM3 UMR CNRS 7239

Salle Marie et Pierre Curie et en Hybride

Site du Technopole - UFR-MIM
Ou en ligne ici : Séminaire GE@2M - 7/12/2023

Voir aussi sur le site de la GE@2M : https://ge-2m.federation.univ-lorraine.fr

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Pierre-Yves HICHER

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Brief Bio-sketch.

Pierre-Yves Hicher, institut de recherche en génie civil et mécanique UMR CNRS 6183 GeM
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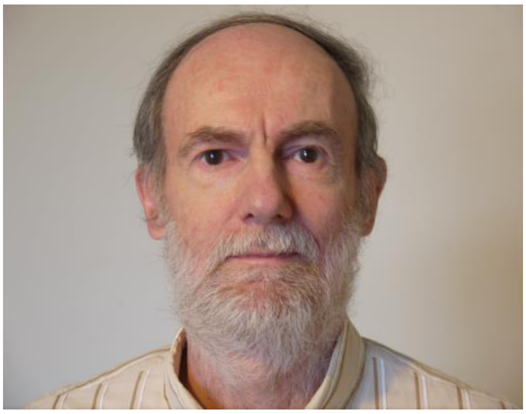

Pierre-Yves Hicher is currently Honorary Professor at Ecole Centrale de Nantes and former Director of the Regional Institute for Research in Civil Engineering and Construction, after having served as Director of the Research Institute in Civil and Mechanical Engineering, UMR CNRS-Ecole Centrale Nantes-University of Nantes. His principal research activity and publications lie in the field of the mechanical behaviour of soils and granular materials, where major contributions to developing a methodology for connecting macroscopic properties to the microstructure of heterogeneous materials can be found. He has also contributed to the knowledge of material properties under complex loading paths by developing original experimental procedures and parameter identification methods under inverse analysis techniques. Recently, he has proposed homogenization techniques adapted to disordered granular materials in the modelling of their mechanical behaviour. They are applied to the analysis of instability and collapse in granular materials, to the size effect in coarse granular materials and its application to rockfill dams, as well as to the impact of internal erosion on the stability of hydraulic works (dams, dykes, levees). He is the author and co-author of more than 150 papers in international journals and has published several books on his research topics. He has supervised 45 PhD theses.

GE@2M
Grand Est
Mécanique Matériaux

Title of lecture.

Hydromechanical Modeling of Internal Erosion in Granular Soils

Abstract.

Geo-structures are subject to hydraulic flows varying in time and space. Water passing through these porous media can cause the detachment and transport of certain particles from the soil constituting the structures and their foundations. This problem is generally referred to as "internal erosion". The term suffusion, a type of internal erosion, refers to the detachment and transport of finer particles through a coarser porous soil matrix due to hydraulic flow. The temporal evolution of suffusion can modify the hydraulic and mechanical properties of soils and can lead to significant changes in the behavior of structures which can eventually cause their failure.
Based on the theory of porous media, a new numerical model was formulated to take into account both erosion and filtration during suffusion. The model was validated by reproducing the main characteristics observed during laboratory erosion tests. To take into account the initial heterogeneity of the soil samples, suspected of having a significant effect in the erosion-filtration process, random finite difference analyzes in 1D and 2D were carried out by applying random field theory to the numerical model of suffusion.
In order to carry out analyzes at the scale of a structure, an elastoplastic model for granular soils was coupled to the suffusion model. The hydromechanical model was implemented in the ABAQUS finite element code and used to evaluate the impact of internal erosion on the stability of structures.
The evolution of suffusion within a dike was analyzed, as well as the effects of the location of a leak cavity. The results showed that two damage mechanisms are possible: a sliding of the downstream part of the dike and a sinkhole developing in the upper part of the dike.
The phenomenon of internal erosion can also affect the stability of natural slopes. On an example studied in the laboratory, we show that the mechanism of instability of the material constituting the slope depends on the percentage of fines and that its reduction by suffusion can lead to the rupture of the slope during imbibition of water by addition from the surface or rise of the water table.

François NICOT

ISTerre UMR CNRS 5275

Professeur des Universités à l'Université Savoie Mont Blanc

Brief Bio-sketch.

Francois Nicot, Dipl.-Ing. PhD, Professor, Savoie Mont Blanc University, Laboratoire ISTerre (CNRS/USMB/UGA), Bourget-du-Lac, France

Dr. F. Nicot is currently Professor at Savoie Mont Blanc University. He received his Engineer and PhD degrees in civil engineering on 1995 and 1999, respectively, at Centrale School of Lyon (France). As a world-renowned researcher in soil mechanics, his activities deal with geomechanics, with a special focus on micromechanics of granular materials and multiscale failure modeling. Application fields span from constitutive modeling of geomaterials to gravity-driven natural hazards analysis, including slope engineering issues. He has published more than 200 articles, including 150 papers in international journals together with more than 20 collective books.

He is deputy director of the International Research Network GeoMech (Multi-Physics and Multi-scale Couplings in Geo-environmental Mechanics), gathering more than 25 academic institutions over the world. He is currently Editor-in-Chief of the European Journal of Environmental and Civil Engineering (T&F Publ.), and he is Associate Editor of Water Science and Engineering (Elsevier – Hohai Univ.) and Granular Matter (Springer Publ.)

Title of lecture.

Shear banding as an optimal dissipative structure from a thermodynamic viewpoint

Abstract.

Granular materials are now known to be an illustration of complex materials as they display emergent macroscopic properties when loaded. An initially homogenous response can bifurcate into a heterogeneous one with the appearance of a rich variety of structured kinematical patterns. The shear banding that ensues illustrates a symmetry-breaking transition with multiple choices of macroscopic behaviours, a common feature of dynamical complex systems. Even though the phenomenon has been studied for decades, this regime transition remains mostly mysterious in geomaterials, with no convincing arguments that could link it to the underlying microscopic mechanisms. The lecture investigates this issue by invoking the extremal entropy production theorems to seek any connection with the second-order work theory in the mechanics of failure. A general equation linking the derivatives of the entropy of a mechanical system to the second-order work is thus inferred, which leads to a thermodynamic interpretation of bifurcations in the failure behaviour of granular materials under a given loading. This is verified through discrete element simulations that highlight the fundamental role played by the elastic energy stored within a granular material before a bifurcation occurs, which also corresponds to a minimization of the entropy production. The analysis suggests a new interpretation of the intriguing shear banding phenomenon as a bifurcation with the emergence of ordered dissipative structures germane to nonequilibrium thermodynamics of open systems.