French Polytech network form for PhD Research Grants from the China Scholarship Council

This document describes one of the PhD subjects proposed by the French Polytech network. The network is composed of engineering schools/universities. The document also provides information about the supervisor.

Supervisor information	
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PhD information	
Title	Study of shrinkage and swelling of clays: coupled approach between modeling and full-field measurement method for the development of a methodology adapted to buildings on shallow foundations
Main topics regards to CSC list (3 topics at maximum)	IV.7 Materials for environment and ecology IV.10 Biomaterials and polymer materials

	IV.12 Environmental behavior and failure of materials
Required skills in science and engineering	Perform experimental tests, perform analytical and numerical analysis, in-depth knowledge of mechanics of materials, analysing and interpreting data, communication, self-Management.

Subject description (two pages maximum including biblio)

The problem of soil swelling-shrinkage is a major geotechnical concern. This phenomenon, also known as "swelling soils", is caused by the presence of swelling clays in the soil, which can retain water and expand accordingly. In China, this problem is particularly widespread in the northern and northwest regions of the country, where climatic conditions favor soil swelling. Expansive soils constitute the most vulnerable natural hazard to buildings on shallow foundations in China. According to incomplete estimation, the houses destroyed by expansive soil amount to a floor space of 10 million square meters and the immediate economic loss exceeds 1 billion US dollars annually [1]. To tackle this problem, prevention and treatment measures are set up in China. This includes the use of special construction techniques to minimize the effects of soil swelling, as well as extensive geotechnical studies to assess risks. Despite these efforts, delayed soil swelling remains a major challenge for geotechnical engineering in China. Finally, even if this problem presents little danger to people, its cost to the community is very high [1]. Indeed, the consequences of delayed soil swelling are multiple and can be serious. Buildings and infrastructure constructed on these soils are susceptible to structural damage due to repeated expansion and contraction of the soil. Additionally, roads and railways can also be deformed, as well as underground pipelines, leading to significant costs in terms of repairs and maintenance. In France, this problem also exists, mainly in areas located in regions with high population density, regions for which the need for new construction is great. In addition, climate change accentuates these phenomena, leading to increased damage to structures and homes. Prevention is therefore of paramount importance in the strategy of costs of curative action. Regulations in France have changed considerably over the last twenty years or so, making it compulsory for any seller of land located in a medium- or high-risk swelling zone to carry out additional tests.

The problem of soil swelling-shrinkage is linked to certain types of clays which react with water and present a significant variation in volume. In fact, they swell when wet and shrink when they dry. This physico-chemical phenomenon is linked to a well-known variable in the field of unsaturated soils: suction. This suction, present in unsaturated soils, is linked to surface tensions at the water-air interface. The “Secheresse 2” project led by Cerema and IFFSTAR showed that the first 3 meters below the surface were mainly affected [2]. Knowledge of these phenomena is still poorly developed since the specific tests aimed at precisely assessing the forces at play during inflation and predicting the volume variations generated are long and expensive. There is no consensus on the most appropriate test to characterize this phenomenon. Many researchers turn to the American standard such as ASTM D 4546-90. In addition, the various studies carried out in recent years emphasize that a generalization of the properties is impossible due to the very different characteristics within the swelling clays and the other soils studied [3,4,5] as part of the project ARGIC [6]. Assessing the risk of volume variations in soils is therefore currently difficult and poorly suited to traditional tests.
The problems of soil swelling-shrinkage being mainly impactful for buildings on shallow foundations and a classic soil analysis representing a substantial budget for private persons, this thesis proposes to develop

a method of simplified characterization of shrinkage/swelling using an original experimental method based on image analyses. Several types of soils without and with different range of agricultural waste-additives will be studied at different scales, based on litterature [7]. An analytical model will also be developed to extract the parameters governing soil shrinkage/swelling, based on experimental campaign. The objective is to optimize new formulations of soils and to propose a prediction model of soils movement in the event of heavy rain or drought.

References:

[1] Shi B, Jiang H, Liu Z, Fang H Y, 2002, Engineering geological characteristics of expansive soils in China, Engineering Geology, Volume 67, Issues 1-2, pp. 63-71.

[2] Mathon D, 2016, Le retrait-gonflement des sols : les recherches récentes entreprises par le CEREMA, 5ème Congrès Maghrébin en Ingénierie Géotechnique (5ème CMIG'16), Marrakech, 26-27 et 28 Octobre 2016.

[3] Nowamooz H, Masrouri F, 2008, Hydromechanical behavior of an expansive bentonite/silt mixture in cyclic suction-controlled drying and wetting tests, Engineering Geology, Volume 101, Issues 3-4, pp. 154-164.

[4] Chrétien M, 2010, Compréhension des mécanismes de retrait-gonflement des sols argileux : approche sur site expérimental et analyse de sinistres sur constructions individuelles, Understanding the mechanisms of shrink-swell of clay soils: experimental site approach and analysis of damage to individual buildings ; PhD thesis, University of Bordeaux

[5] Andrieux C, Chrétien M, Denis A, Fabre R, Lataste J-F, 2011, Shrinkage and swelling of clay soil. Comparison between laboratory and in situ measurements, European Journal of Environmental and Civil engineering, Volume 15, pp 819-838.

[6] Kazmierczak J-B, Maison T, Laouafa F, Delalain P, and Fleureau J-M (2016) A new device for characterizing the shrinkage and swelling of clay soils: Revue Française de Géotechnique, No. 147, p. 1.

[7] Gidebo, F.A., Yasuhara, H. & Kinoshita, N. (2023) Stabilization of expansive soil with agricultural waste additives: a review. Geo-Engineering 14, 14.