Doctoral thesis offered in the GERS-SRO laboratory at the Université Gustave Eiffel

"Behaviour of foundation soils in the face of clay shrinkage and swelling".

The Université Gustave Eiffel, which was formed from the merger of the Université Paris est Marne le Vallée and IFSTTAR, is a major player in European research into cities and regions, transport and civil engineering. It conducts targeted research and expertise in the fields of transport, infrastructure, natural hazards and cities, with the aim of improving living conditions and, more broadly, fostering the sustainable development of our societies. As part of the GERS department (Geotechnics, Environment, Natural Hazards and Earth Sciences), the SRO laboratory (Soils, Rocks and Geotechnical Works) brings together 14 research managers working in the fields of geotechnics, natural hazards, soil mechanics and geomaterials, particularly the physical chemistry of soils. The laboratory's remit covers applied research in the field of geotechnics, expert appraisals and unusual testing services (such as foundation loading tests and shear tests using specific protocols), consultancy and support for public services, in particular the Ministry of Ecology's Directorate-General for Risk Prevention, as well as training and standardisation, working closely with the professional world of public works.

To carry out its missions successfully, the laboratory relies on a three-pronged approach: observation (on site or on samples), experimental study (on site or in the laboratory using the multi-scale testing platform for soils, rocks and geotechnical structures) and numerical modelling to analyse and predict the behaviour of soil masses and structures.

It is in this context that the doctoral student recruited will be able to contribute to a better understanding of the
"This is a major phenomenon, with one home in two in France exposed to shrinkage and swelling of clay soils, leading to cracks in buildings. A widespread phenomenon, with one in two detached houses in France exposed to the shrinkage and swelling of clay soils, and therefore to cracks in their buildings, there is an urgent need to find ways of reducing, preventing and remedying these effects, which can only intensify with climate change. Although the ELAN law adopted in 2018 makes it compulsory to carry out a geotechnical study before selling a building plot and before building a house on soil susceptible to shrinkage and swelling (medium and high risk), the measures taken do not seem to be able to curb the pathologies. Article 68 of the ELAN law does indeed help to reduce the damage caused by new buildings, but it does not affect existing buildings, which make up the majority of those affected by drought. We therefore need to answer the following two questions: (1) Are the measures currently proposed in the recommendation guides dealing with the RGA problem sufficient? (2) Should new measures be taken into account, and if so, which ones?

The work in this thesis on the impact of climate change on foundation soils should provide answers to these two questions, which represent a major challenge for the French economy, since the damage is worth billions of euros nationwide.

This thesis has two objectives:

- the study of changes in the load-bearing capacity of soils (fatigue) under a surface foundation under the effect of wetting/drying cycles (effect of the intensity and accumulation of cycles).
- Proposal, development and validation of measures to reduce the effects of the shrink-swell hazard, with a view to minimising its impact on light construction, as stipulated in the ELAN law.

The objectives will be achieved by drawing on existing experimental data, laboratory experiments, physical model tests (on a reduced scale) and numerical simulations. After an analysis of the bibliography to complement the previous work carried out in the laboratory, the tests in the SRO laboratory will include the characterisation of a set of soils taken from the commune of Champs-sur-Marne, partners in the REMED-RGA project which supports this thesis (shrinkage and swelling tests taking into account the value of the load transmitted by the foundation to the underlying soil). This will be followed by the finalisation of a reduced model (multi-decimetric scale) to monitor changes in the bearing capacity of soils (as characterised above) under a superficial foundation subjected to climatic changes, after several cycles of drying-wetting accompanied by the appearance of cracks and the penetration of water under the foundations.
With regard to the development of innovative prevention/remediation methods, after identifying methods that act on the environment of the structure (management of water and vegetation), on the structure itself (stiffening and underpinning) and on the soil (treatment to reduce its sensitivity to water), a method will be developed and tested: it consists of modifying the mechanical characteristics (bearing capacity) of the soil beneath the foundations using a column of sand injected with an enzymatic solution that promotes bio-precipitation.

Finally, the third part of the thesis work consists of synthesising the data from the experiments and case studies collected in the bibliography. These will be used to populate the COMSOL database and model the impact of climate change on the strength and deformability of soils under a foundation, taking into account variations in water content. This phase includes numerical modelling of soil-atmosphere interaction and soil-foundation interaction. The aim is to gain a better understanding of the hydromechanical behaviour of a clay soil subjected to climate change (with scenarios to be defined with varying intensities and changes in soil behaviour under the cycles). Modelling of the effects of existing prevention and remediation methods for reducing variations in soil water content (assessment of their effectiveness and limitations) will be addressed from a numerical point of view, as will the effectiveness of the innovative solution using bioprecipitation described above. The modelling of mixed solutions, i.e. a coupling between simple methods and innovative methods, will finally be addressed (parametric study). The results of the numerical approach will be compared with the results obtained on a full-scale demonstrator developed as part of the RGA project (construction of a house) and will be used to compile a catalogue of solutions and their effectiveness in combating the effects of RGA. The development of an application to assess a building's sensitivity to RGA could also benefit from these results.

1. How it's done

- The duration of the thesis is 3 years from October 2024,
- The PhD student will be working at the Université Gustave Eiffel in Champs-sur-Marne, and accommodation in the Ile-de-France region is required,
- The work will involve travel and interaction with external players (construction sites, Maries, d e s i g n offices, laboratories, etc.).

2. Expected profile

The candidate should have a 5-year degree in geotechnics or an engineering degree.

3. Application

You can submit your application (CV, covering letter, grades from previous years, any letters of recommendation) before 12 July 2024 to
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