Université Gustave Eiffel

Doctoral thesis offered in the MAST- laboratory
EMGCU/GERS-SRO
Gustave Eiffel University

"Behaviour of lightweight structures in the face of clay shrinkage and swelling (RGA)".

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. Within the MAST (Materials and Structures) department, the EMGCU laboratory (Le laboratoire d'Expérimentation et Modélisation du Génie Civil et Urbain) brings together 13 research managers working in the field of civil engineering, specialising in research and development and expertise focused on the life cycle and safety of civil engineering and building structures. Its research focuses on concrete materials and structures, from their design to their end-of-life, including the detection of anomalies and innovative ways of remedying them. EMGCU works closely with the GERS department (Geotechnics, Environment, Natural Hazards and Earth Sciences). The SRO laboratory (Soils, Rocks and Geotechnical Structures) 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 missions cover applied research in the field of geotechnics, expert appraisals and unusual testing services using specific protocols, advice and support for public services, in particular the Ministry of Ecology's risk prevention department, as well as training and standardisation missions, working closely with the professional world of public works.

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 in two French detached houses exposed to shrinkage and swelling of clay soils, and consequently to cracks in their buildings. A widespread phenomenon, with one in every 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. It is therefore necessary 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 light constructions subject to the shrinkage and swelling of foundation soils should help to answer these two questions, which represent a major challenge for the French economy, since the damage is worth billions of euros on a national scale.

This doctoral thesis will be carried out as part of the REMED RGA project, funded by ADEME (the France 2030 plan), which focuses on: "The effectiveness of existing and innovative measures to remediate/prevent the effects of RGA on old buildings".

The objectives of this thesis are twofold:

-The first point will be to gain a better understanding of the overall behaviour of a light structure founded by means of superficial foundations on clayey soils, by determining the additional actions (loads, horizontal and vertical forces, etc.) to be taken into account and applied to the structure in order to dimension the various elements **(** beams, columns, chains, etc.).
-The final objective will be to suggest measures to reduce or avoid the severity of the shrink-swell hazard, with a view to minimising its impact on light construction, as stipulated in the ELAN law.

A doctoral thesis on the geotechnical aspect will start at the same time as this thesis. The two PhD students will work together on the soil-foundation/structure interaction section. The work of the two theses will contribute to the design of a demonstrator (a house) in Champs sur Marne, which will be used to validate the full-scale reinforcement solution developed during this thesis.

Several aspects will be explored in the course of this PhD, based on existing data, field surveys (diagnosis of damaged houses) and numerical simulations. The approach that will be implemented will include:

-Firstly, an analysis of the damaged houses in Champs-sur-Marne, selected according to their type. These structures will be subjected to several stress scenarios in order to reproduce the disorders observed on the buildings. Particular attention will be paid to the most common faults and those identified after the auscultation and field survey and the analysis of the files of the damaged houses in the municipality,

-the second part of the work will be devoted to the repair solutions (type of structural reinforcement, location, sizing, etc.) to be proposed for each type of house studied (around ten cases will be selected in the commune of Champs-sur-Marne). One or more repair solutions will be proposed for each type of house and the effect of the reinforcement will be studied by numerical modelling (parametric study and study of different alternatives). The software to be used will be GRAITEC and SCIA (in conjunction with a structural design office). The aim is to create a database of simple techniques for remedying/preventing the effects of RGA on individual houses, with a ranking of their degree of effectiveness (based on their cost, durability and technical nature).

-the third phase will synthesise the data from the experiments and the cases collected during the diagnostics of the damaged houses. These will be used to feed the COMSOL software database in order to carry out a "mixed" or complete modelling of the soil-foundation-structure interaction, by coupling the behaviour of the structure (house) in response to the implementation of solutions affecting the soil/foundation (in particular the innovative solution of the type of sand column injected with enzymatic solution used to improve the bearing capacity of the soil) and one or more solutions for reinforcing the structure. The solution selected and validated for the most unfavourable climatic stress scenario will be the solution applied to the full-scale demonstrator in order to validate its feasibility and effectiveness.

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 structural engineering (civil engineering) 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 TRAN Le-Hung (Supervisor le-hung.tran@univ-eiffel.fr), CHESNAIS Céline (Supervisor celine.chesnais@univ-eiffel.fr), MAKKI Lamis (Supervisor lamis.makki@univ-eiffel.fr), SCHMIDT Franziska (franziska.schmidt@univ- eiffel.fr, thesis supervisor), REIFFSTECK Philippe (Co-thesis supervisor, philippe.reiffsteck@univ- eiffel.fr).