École des Ponts
ParisTech

PhD Position

Investigating the cyclic thermo-mechanical behaviour of an energy pile subjected to combined loading by using field tests and load transfer method

The growing energy needs of urban areas and the environmental context lead to the development of new energy technologies. In particular, since the 1980s, a new geothermal method has been developed: energy geostructures, consisting in fixing heat exchanger pipes to the reinforcement cages of geotechnical structures like foundations to extract/inject the heat from/into the ground with the purpose of meeting the building heating and cooling demands. Among them, energy piles have been widely studied because their thermal behaviour is quite similar to the one of usual Ground Source Heat Pumps, with the specificity of a dual function: structural support and energy exchanger. These studies provide knowledge about mechanical behaviour mainly upon the axial direction and about the assessment of the energy performance of the system, but energy piles installation is still held back by the uncertainty of their thermo-mechanical behaviour despite all economic and ecological advantages of this technology. Furthermore, their dual role sparks some apprehension among the stakeholders. Among uncertainties, one of the questions still unanswered concerns the adaptation of design under combined lateral and axial loads, meaning the mutual effect between lateral (respectively axial) loading and axial (respectively lateral) behaviour of energy piles, coupling to volumetric thermal loading acting on surrounding ground and along the pile. **This thesis aims at characterizing the effect of combined loading on energy piles and at the development of open-source and easy-to-use design tools for energy piles, capable of constructing an overall failure envelope including thermal cycling loading effects**.

Two methods will be used. First, tests will be performed on two experimental energy piles (0.42 m in diameter and 12 m in length) in the campus of Ecole des Ponts ParisTech. The piles will be initially subjected to axial static compressive load (10, 20 or 40% of the ultimate axial load) and then in the subsequent stage, horizontal static load will be incrementally applied (30, 50 or 70% of the ultimate horizontal load), while the axial load is kept constant. At each level of horizontal load, to simulate the actual operating condition of energy piles, ten thermal cycles with temperature variation of -/+ 10 °C will be repeatedly applied to the piles while the mechanical loads are maintained constant. Second, the results from the experiments (and other results of the project ANR COOP) will be used to develop an open-source simplified design tool to bridge the gap between research and engineering practice. The principal goal of this application will be to determine a 3D failure envelope corresponding to the energy pile combined axial and lateral response and accounting for thermal cyclic loading. This envelope will then be used to design foundation systems including energy piles.

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Net salary: ≅ 1,700 € /month (36 months)
Supervision:
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Candidate profile: MSc degree in Civil Engineering or Geotechnical Engineering.
Application (CV, letter of motivation, letters of recommendation) to be sent to Dr. A.M. Tang (anh-minh.tang@enpc.fr) before April 1, 2023.

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