Intelligent realisation of ground energy

There is a need to reduce the economic cost of the energy geostucture and increase the efficiency such systems, which will also rationalise the environmental impact.


More than 300 constructions in Europe use thermal piles, accounting for the wide success of the principle of soil-energy storage. The knowledge of energetic dimensioning of these systems is such that custom sizing tools are already available for assessing heat-pump in order to err on the side of caution. Safety factors applied to the design of thermo-piles are generally twice the values used for classical piles, obviously affecting construction costs downstream. Clearly, there is room to improve this empirical

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In order to avoid unnecessary risks, it is important to understand the energetic performance of the heat-exchanger structure, which is often underestimated. The calculations are often based on sets of classical, geothermal earth probes in which only heat transfer is considered. Then, the method is simply applied to installations with heat-exchanger piles. As a consequence, the energetic performance of the heat-exchanger structure can be significantly reduced with respect to its real potential. Moreover, geotechnical engineers will systematically over-estimate the dimensioning of concrete heat-exchange piles.

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GEOTHERMAL LIVE! TALKS

Prof Laloui will present two papers at Geothermal Live! on May 1: ‘Formation thermal conductivity testing’ in the session at 9.05-10.30am; and ‘Experimental and numerical investigations of the behaviour of a heat exchanger pile’ in the session taking place 2.05-3.30pm.

design method in order to reduce the economic cost of the energetic geostucture on the one hand and increase the energetic efficiency of the system on the other, which will also rationalise the environmental impact.

As geotechnical engineers, we are concerned by the complexity of soil materials, whose mechanical behaviour is everything but linear and reversible, and which host many multi-physics processes. The core issue to focus on here is the modification of soil mechanical behaviour upon temperature changes.

Our research activities on the heat-exchanger piles theme are then aimed at providing the correct answers to the actual questions from practitioners. By the means of in situ full-scale testing, modelling and developing numerical tools, we are now able to quantify the long-term effects of cyclic temperature variations on the bearing capacity of a concrete pile. Interestingly, we can prove, for instance, that temperature increase enhances the performance of the pile and the resilience of the soil under cyclic loading (such as earthquakes).

“The ultimate, scientific challenge is now to provide a practical design tool that combines the energetic geostucture and building-service behaviour with the thermo-hydromechanical behaviour of the soil”

We also offer our expertise out of the Ecole Polytechnique Fédérale de Lausanne laboratory (EPFL), by carrying out in situ thermal-response tests. Such tests provide an effective method to determine the ground-thermal properties required for the design of a geothermal-energy installation. This service is based on a unique, compact, testing device for in situ thermal-response testing (see figure 2).

The understanding of fundamental aspects of heat storage in soils and soil-pile interactions contributes to rationalising the design process by reducing the applied safety factors significantly. For this purpose, the development of a numerical tool taking into account a wide range of thermo-hydromechanical couplings arising in soil is essential.

If the applicability of our conceptual approach to heat-exchanger structures has been demonstrated, the ultimate, scientific challenge is now to provide a practical design tool that combines the energetic geostucture and building-service behaviour (temperature and loads) with the thermo-hydromechanical behaviour of the soil. Once optimised from both an energetic and a mechanical viewpoint, the heat-exchanger geostucture will become one of the most intelligent and cost-effective methods to valorise the intrinsic soil energy.

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