EGU21-12890
https://doi.org/10.5194/egusphere-egu21-12890
EGU General Assembly 2021

Centrifuge modelling of a non-symmetrically heated concrete energy pile group with raft

Badr Ouzzine[1], Jean de Sauvage[1], Iheb Ghandri[2], Giulia Viggiani[3], and Gopal Madabhushi[3]
[1]Univ. Gustave Eiffel, GERS-SRO, Univ Gustave Eiffel, IFSTTAR, France (badr.ouzzine@univ-eiffel.fr)
[2]Polytech' Sorbonne, France (ghandri.iheb@gmail.com)
[3]University of Cambridge, UK (mspg1@cam.ac.uk)

The growing energy needs of urban areas and the current environmental context have led to the development of new energy technologies. Since the 1980s, energy geo-structures have been developed and applied, in which heat exchanger pipes are attached to the reinforcement cages of geotechnical structures such as pile foundations or diaphragm walls. By circulating a heat transfer fluid in these pipes, and using a heat pump, these low-enthalpy solutions make it possible to produce heating and cooling with significantly reduced CO_2 emissions. However, the cyclic thermal loading generates stresses and strains in the geo-structure and in the surrounding soil, due to thermal expansion. Research on the behaviour of energy pile groups is rather limited, particularly for piled foundations in which only a few piles within a group are thermally activated. Indeed, the implementation of this type of energy technology is slow because of the many concerns about the impact of thermal cycles on the mechanical behaviour of the piles. The complexity of this problem is increased if a natural groundwater flow is present, as this has the potential to affect significantly heat transfer between piles in the group.

To tackle these questions, the stresses induced in pile groups by thermal activation were studied by geotechnical centrifuge modelling. Two reduced scale models of 2*2 pile groups were examined, one in dry and one in saturated Hostun sand. In the tests, only one pile was subjected to cyclic thermal loading, but all the pile heads were connected to the same raft. The model piles were cast in cement and copper pipes were used to model simultaneously the reinforcement cages and the heat exchanger pipes. This modelling highlighted that, when heated, the energy pile goes into additional compression along with the diagonally opposite pile, due to the raft rotation. The other two thermally inactive piles showed a decrease of axial load. The saturation of the sand layer displayed a strong role not only on the transient response, but also on the thermal equilibrium due to additional thermal inertia.

In order to make relevant comparisons between the observations made on the reduced scale models and those made at prototype scale, scaling laws must be respected, so that the model and the full-scale structure undergo the same physical phenomena. Therefore, preliminary theoretical work was carried out to examine the various thermal phenomena involved. For each phenomenon of interest, the quantities that allow keeping dimensionless numbers identical or at least of the same order of magnitude are studied. Some phenomena were verified also numerically or experimentally. This work is presented in the form of a catalog of scaling laws derived for both mechanical and thermal behaviour of pile foundations.