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EXTENDED ABSTRACT

Thermo-Mechanical Behavior Analysis of Heat Exchanger Piles by Numerical Modelling

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1. Introduction

Using renewable energy sources instead of fossil fuels is a fundamental way to reduce environmental pollution caused by greenhouse gases. Geothermal energy is available all over the world and has an important role in the supply of renewable energy. In order to collect geothermal energy various heat exchanger systems have been developed in recent years that thermal activated piles (energy piles) are one most of them. Reinforced concrete piles have been widely used as a geothermal heat exchanger to access the relatively constant temperature of the ground for efficient heating and cooling of buildings. Energy piles are heat capacity systems that have been increasingly exploited to provide both supplies of energy and structural support to civil structures (Batini et al., 2015). Concrete has a good thermal conductivity and thermal storage capacity, which makes it an ideal medium as an energy absorber (heat exchanger). To use these properties for energy foundations, high-density polyethylene plastic pipes have to be installed within the concrete. The plastic piping can be fixed to the reinforcement cages of the energy foundation in a plant or on the site (Fig. 1).

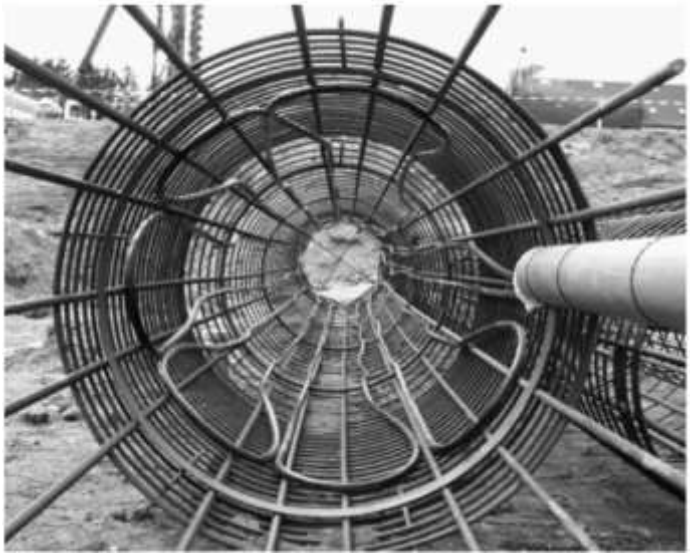

Fig. 1. Absorber pipes fitted to the reinforcement cage of a large-diameter bored energy pile (Brandl, 2006)

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2. Methodology

There are three major ways to analyze the behavior of geothermal piles, as following: Full scale In-situ tests; Laboratory scale and centrifuge modelling; and Numerical Simulation and Analysis (Dubey and Kumar, 2017). In this paper, the geotechnical challenges of the energy pile and the thermo mechanical behavior of this system were investigated using the finite element software ABAQUS (V.6.14). Fig. 2 displays geometry of pile and soil and the Finite Element mesh for present simulation. The resulting soil-structure interaction is investigated through these analyses. The stress-strain response of sand is simulated herein using the Mohr-Coulomb constitutive model. Mechanical behavior of energy piles is simulated using the concrete damage plasticity model. This study focuses on investigating the impact that different magnitudes and combinations of thermal and axial mechanical loads have on the mechanical behavior of energy piles in dry sand. The thermal load was applied on the pile as a temperature change of 15º-32º(ΔT=17ºC).

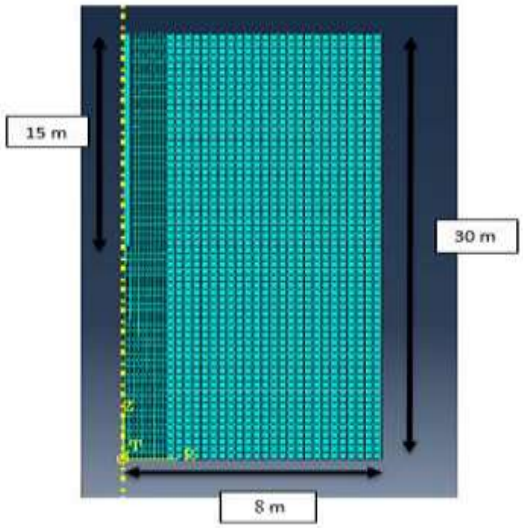

Fig. 2. Geometry of the pile and soil domain and the used finite element mesh

3. Results and discussion

Due to the application of the pile's thermal loading, the pile's resistance parameters are changed. In this paper, the effects of temperature changes on the axial stress, shaft friction stress, axial displacement, axial strain, and the limit load of energy piles are carried out and sensitivity analysis for understanding the behavior of energy piles in the different thermal and physical characteristics of sand were carried out. The results of numerical modeling show that, due to the application of temperature loading, the amount of bearing capacity of the pile is reduced by about 11%. In addition, the thermal properties of the soil have a profound effect on thermal and geotechnical performance.

4. References

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