Thermal response test of floating energy pile in China: Case study

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Abstract

Energy pile, which is combined with pile foundation and ground source heat pump (GSHP) system, can play the double role of structural support and heat exchanger with the ground. Series of field tests on the thermo-mechanical behavior of energy piles were carried out. However, the thermal response on floating pile was still little. Hence, the thermal response test on one floating energy pile (with 23.5 m length, and 0.6 m diameter), located in Nanjing, China, was carried out. The inlet and outlet water temperatures, the distribution of temperature and strain along pile depth were measured and discussed.

Introduction

In recent years, a series of full-scale in situ tests on the thermo-mechanical behaviors of energy piles were carried out (Bourne-Webb et al. 2009; Mimouni & Laloui 2015; Rotta Loria & Laloui 2016; You et al. 2016). These field tests and measured data are very useful for the design and application of energy piles. Although many field tests on energy piles were carried out in the world, the thermal response on floating pile was still little, especially on floating pile embedded in soft ground. Hence, this paper focus on the thermal response test on floating energy pile. One floating energy pile with 23.5 m length and 0.6 m diameter, which is located in Nanjing, China, was carried out. The thermal response contains temperature and strain were measured and discussed.

Thermal response test procedure

One field test on the thermal response test of friction energy pile was carried out in Nanjing, China. The energy pile was 600 mm in diameter and 23.5 m in length. The pile concrete strength grade was C20. Photos of construction site (contains reinforced cage, heat transfer tube, sensors and insulation pipe) were shown in Fig. 1. Both thermal and strain sensors were installed in 12 sections, at each 2 m length from the pile top to the bottom, to monitor the temperature and stress change along the energy pile. The soil was classified as layered clay of low plasticity (CL), clay of high plasticity (CH) according to the Unified Soil Classification System (USCS).

Double W-shaped pipes connected in series were incorporated into the piles. The pipes were made of high-density polyethylene (HDPE) and had a diameter of 25 mm, a thickness of 1 mm and a length of 94 m. Thermal temperature test was conducted with 2.5 kW heating power, 0.7m^3/h water flow velocity.

Field test results and analysis

The water temperature of inlet and outlet of heat transfer tube was shown in Fig. 2. The air temperature during 15 days testing time was also shown in Fig. 2. It shows that the water temperature of inlet and outlet of heat transfer tube improved quickly with several hours, and then trend stable. The temperature change characteristics of outlet water is similar with that of inlet water. Based on the average temperature of inlet and outlet, the comprehensive thermal conductivity coefficient of in-situ soils can be obtained. According to relevant regulations, the average water temperature of the import and export of 120h to 360h was intersected with the curve of time log, and the slope of the fitting curve was 3.565. The comprehensive thermal conductivity coefficient of the energy pile was estimated as 2.330W/m℃, which is difference with the average soil thermal conductivity 1.538W/m℃ measured in the laboratory.

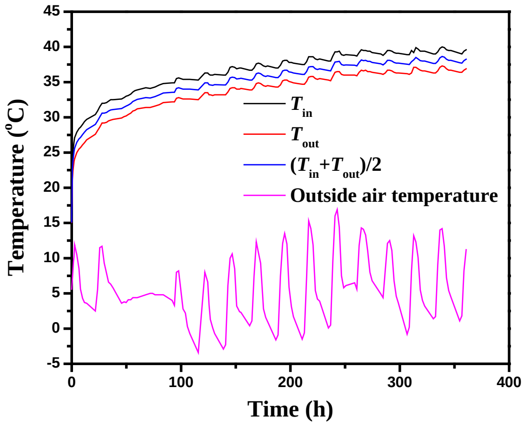

Fig. 1: Photos of construction site

Fig. 2: Inlet and outlet water temperature

Conclusions

According to the change rule of the average water temperature of energy pile import and export with the time log, the comprehensive thermal conductivity coefficient of the energy pile was calculated to be 2.330 W/m°C, according to the change rule of the average water temperature of the energy pile. This is difference with the soil thermal conductivity of 1.538 W/m°C measured in the laboratory.

References

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