SSRG International Journal of Civil Engineering
ISSN: 2348 – 8352 /doi:10.14445/23488352/IJCE-V6I2P101

Volume 6 Issue 2, 1-3, February 2019

Geotechnical Impacts of Energy Piles

Wassef Ounaies

Jouf University, College of Engineering, Civil Engineering Department
P.O.Box 2014, Al-Jouf, Skaka, Kingdom of Saudia Arabia.

Abstract

Types of pile construction are usually large public, industrial or apartment buildings. According to the periods of the year, this type of building has great needs for heating or cooling, which are well suited at first glance to energy piles.
Despite the growing number of energy geo-structures already operational, their design remains mainly based on recommendations. There are still no standards allowing a true geotechnical dimensioning; this deficiency is mainly attributable to the still limited knowledge of this type of structures' thermomechanical behavior. Moreover, their impacts on soil and groundwater are not sufficiently studied. These issues will be investigated in this paper.

Keywords — *Energy pile, impact, soil, heat,* Geotechnical Impacts.

I. INTRODUCTION

It is now known that geostructures in contact with the ground: tunnels anchors, foundation slabs, deep foundations, and retaining walls, can be used to exchange heat with the ground.

Concrete building elements are intended to be load-bearing or architectonic elements: Concrete can indeed be used as accumulator and heat conductor.

In Austria and Germany, concrete elements in contact with the earth have been used in recent years as heating and cooling systems that are both functional and economical, an application related to the use of energy piles for the heating. In principle, it is, therefore, possible to apply this principle to each concrete surface in contact with the ground. However, the installation of heat exchangers thermal can only be done as part of the building's construction itself. Retrofitting of existing concrete surfaces is not possible.

The additional cost of using the building elements concerned as a source of heat is relatively low. The economic benefit comes primarily from the fact that such building elements must, in any case, be built for static reasons. This eliminates the need for drilling necessary for collectors and geothermal probes. In this article, we will present the advantage of energy piles and the limits of such a solution. We are interested in our research work on the impact of energy piles on soils and buildings.

II. PRINCIPLE

Promoting Green building is a challenge to preserve our environment [1]. The principle of an energy pile is transforming a conventional retaining pile into a source of heat.

The heat exchanger function to a structural element can be done with all elements in contact with the ground. The storage capacity and thermal conductivity of concrete and reinforced concrete are ideal for absorbing the ground's calories.

These energy piles then have 2 functions. The first is to take over the expenses of the construction. The second is to ensure very low energy costs by adding exchanger tubes in the pile, the heating, and cooling of the building.

The pipe network, as shown in Fig. 1, installed with the piles, captures the energy of the ground thanks to a coolant contained in it. The different networks are connected to a heat pump.

Fig1: Energy Piles structure

The types of pile constructions are generally large public, industrial or collective buildings. This type of building has high heating or cooling requirements, which is good for energy piles.

The heat transfer fluid circulates in a closed circuit between the piles and a manifold connected to the heat pump. A Thermal Response Test makes it possible to determine the parameters precisely and at the exact site of the operation for reliable and optimal sizing. The cooling capacity can be estimated at 30 W / m of the pile, and this value can increase by 50% by the presence of a water table.

The various components of a thermal pile are as follows:

A. The heat pump system

The heat pump system must be made of a stable material over time with good thermal properties and must withstand hot, cold, corrosion, and concrete. Ground-source heat pump (GSHP) systems can achieve a higher performance coefficient than a conventional air-source heat pump [2]. It must also have good chemical resistance, low hydraulic resistance, and an attractive price. Polyethylene is a material that has many of these properties and is, therefore, the most used material for heat exchange. But its thermal conductivity is bad enough, it must be reduced to a minimum thickness, but it must always be sufficient to withstand the efforts that require it. It is logically the diameter and the length of the pile, which influence its thickness. The exchanger tubes have a thickness rotating around 1.5 to 2.5 mm for an outside diameter ranging from 16 to 32 mm. The tubes are placed in U, their number varying according to the diameter of the pile. Indeed, the diameter makes it possible to modify the spacing between the tubes. This spacing must follow certain rules to have an ideal performance.

B. The heat transfer fluid

Contrary to general expectation, increasing the heat transfer, fluid velocity does not significantly impact the overall exchanged energy [3]. As shown in Fig. 2, this fluid circulates in the closed-circuit between the piles and a manifold connected to the heat pump. The fluid is composed of either clear water or a mixture of water and antifreeze. Clearwater is rarely used because there is a risk of freezing the heat exchanger. If the liquid is usable only at certain periods, the duration of use of the system decreases. The mixture of water and glycol (20 to 30%) allows a permanent use of the system.

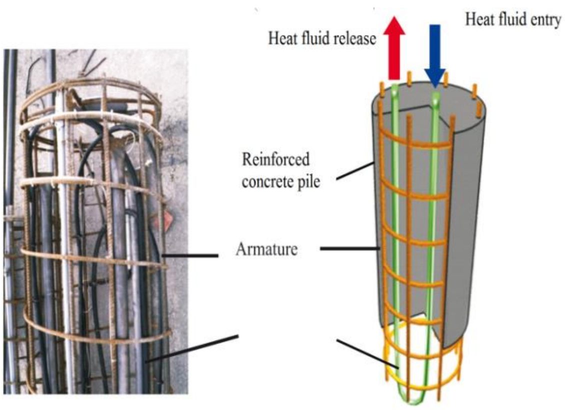

Fig 2: Heat fluid transfer

III. GEOTECHNICAL IMPACTS

The extra cost of transforming piles into energy piles is low for a building requiring, in any case, the construction of piles and using a traditional heating system.

However, the use of these structures for energy purposes induces additional thermal stresses (stresses and deformations), which can be important and must be taken into account during the design.

Despite the growing number of energy geo-structures already operational, their design remains mainly based on recommendations. There are still no standards allowing a true geotechnical dimensioning; this deficiency is mainly attributable to the still limited knowledge of the thermomechanical behavior of this type of structure [4]. The use of foundations to ensure the exchange of heat with the soil causes a change in soil temperature and structure. This phenomenon is not without consequences on the overall functioning of the system. Although this technology has been recently applied in various countries, there are still important knowledge gaps on the consequences of the application of such technology because of the potential risks that might arise due to unforeseen induced cyclic thermal stresses making construction companies reluctant to apply energy piles in daily practice [5].

Excessive heat extraction can lead to freezing of the ground and thus to a loss of lift of the foundation piles. The risks are more serious for thermoactive slabs that can rise or fall.

On the other hand, an excessive thermal recharge of the thermoactive foundations, linked to excessive cooling of the building, can lead to a gradual rise in the soil's temperature.

In both cases, the effects on the groundwater can be rather harmful: modification of the equilibrium constants of the mineral substances, decrease or increase of the anaerobic germs' activity.

Ideally, for a combined heating and cooling system, small groundwater flows, if present, is sufficient to prevent freeze-up in the winter, but this flow must be limited to prevent energy loss.

In this case, with a thermal recharge of 70% to 90% of the extracted energy and a thermal conductivity of the ground of 2.3 W / mK (corresponding to saturated sand or gravel), the extraction of heat by the piles is 30 W / m at 35 W / m exchanger pile or 65 kWh / m.year at 80 kWh / m.year.

The heat injection into the piles (cooling) must be a maximum of 30 W / m on average, i.e., approximately 20 kWh / m-year at 60 kWh/m-year.

If the cooling thermal recharge is greater than 90% of the energy extracted, direct cooling (geo cooling) is no longer possible. Indeed, there is no compensation for gains in the land due to heat losses of the building, and there is a gradual increase in the average temperature of the land year after year.

On the contrary, if the thermal recharge is less than 70% of the energy extracted, there is a gradual decrease in the average temperature of the ground year after year, resulting in a depletion of the soil.

IV. CONCLUSION

Our study allowed us to make several observations; the main role of this foundation system remains to ensure the building's stability. Indeed, energy savings alone do not justify the use of this type of foundation. Second, the geological and hydrogeological characteristics are of paramount importance because they condition the quality of thermal exchanges between the ground and the energy piles and, therefore, decide to use this technique. Also, the position and the number of the tubes and the properties of the constituent materials, although having a lesser influence on the performances, can be optimized to maximize the exchanges between the coolant and the ground.

REFERENCES

[1] W. Ounaies, Energy Piles Contribution on a Green Building Context, SSRG International Journal of Civil Engineering 5(2),(2018),10-12.

[2] S. Kentaro, et al., Development of a Ground-Source Heat Pump System with Ground Heat Exchanger Utilizing the Cast-in-Place Concrete Pile Foundations of Buildings. ASHRAE Transactions., 113.1,(2007).

[3] F. Cecinato, F.A. Loveridge. Influences on the thermal efficiency of energy piles. Energy 82, (2015),1021-1033.

[4] L. Laloui, A. Di Donna - Energy geostructures: innovation in underground engineering, (2013) - John Wiley & Sons.

[5] R. Zagorscak, H.R. Thomas. A review of the performance of energy piles and effects on the surrounding ground. Inzenjerstvo Okolisa (Environmental Engineering) 3(1) ,(2016), 33-45.