SUCCEsS – Sustainability of Shallow Geothermal Systems. Applied Studies to Southern Europe Climates

Summary

Managing energy resources and the environmental impacts resulting from its exploitation are major concerns of modern societies. The search of renewable energy sources has been increasingly promoted, especially in the last few decades. Geothermal energy is one of those sources and has been intensively used for buildings and infra-structures conditioning. Besides the economic and environmental advantages, climate change mitigation and adaptation are also challenges for a near future.

Shallow Geothermal Systems, the usually called Ground Source Heat Pump (GSHP) use the ground as a heat exchanger and storage medium rather than a heat source. Among shallow geothermal systems, the so-called thermoactive geostructures are recently experiencing exponential growth in Europe, especially in central and northern countries. This category includes all the ground-embedded structures, such as tunnels, anchors and linings, shallow foundations, piles and diaphragm walls, used to exchange heat with the ground as well as borehole heat exchangers (BHE).

The design of these systems is interdisciplinary evolving thermal, mechanical and hydraulic soil and concrete characterization, definition of the atmospheric conditions in place, operating system thermal action definition, as well as the overall energy demand for the building or facility to be conditioned. These in turn are dependent of the specific features of the building (sun exposure, ventilation conditions, insulation among others). Integrating all these aspects aims to optimize the system's performance by minimizing the costs and the environmental impacts.

Besides evaluation of the heat flows between the ground and the concrete structures, the thermo-mechanical effects must be accessed ensuring system operation without affecting safety and functionality, being necessary to study on the long term the changes induced in the soil temperature field and the structural safety of the foundation elements. For that purpose, an appropriate knowledge on the thermo-hidro-mechanical behaviour of the soil must be attained.

The main purpose of this Project is to analyse in an integrated manner all the parties involved in the performance of a building with GSHP and numerically reproduce its overall behaviour. For that purpose, it will be used a case study (prototype), consisting of a building located in Aveiro University (UA) campus for which a series of information is available.

The study to be carried on will involve the primary circuit characterization (the part of the system in contact with the soil) and the secondary one (building) and the numerical reproduction of its seasonal overall behaviour.

The case study building has an Energy Management System that collects data from several sensors, with three years of historic data from the building and geothermal system and also from a weather station nearby in university campus. Despite this amount of data, to validate the energy plus building energy model (BEM) to study this kind of building and to further develop optimization studies, more detailed data is needed, and in this research project it's foreseen to install more sensors and develop a detailed campaign to assess building use and its characteristics and performance. With those data, it will be possible to validate the BEM model to simulate the geothermal system and the building and conduct a more detailed study of geothermal system and its interaction with the building. It will be assessed the need to integrate specific geotechnical models with energy plus, or if it's enough to use proper soil characteristics with energy plus.

The reproduction of the integrated behaviour of the system also requires detailed information on the primary system. To characterize the ground behaviour a series of laboratory tests on the same soil formation as the CICFANO building will be carried out. In order to obtain the temperature around the building´s thermoactive geostructures an in-depth monitoring temperature system is predicted. It will consist in of arrays of thermocouples installed in 5 boreholes (in one of which samples will be extracted), close to the piles, to be executed within the project´s activities.

With the data of the overall system in operation its behaviour will be numerically reproduced in an integrated manner and its sustainability and energy efficiency evaluated. In a further stage with the models properly calibrated, other analyses will be carried out for other climate and soil foundation conditions (other cities in Portugal), another geothermal systems and building typologies.

This project presents as innovative aspects the detailed and integrated analyses of the sustainability of the global geothermal system, for the specific conditions of the Portuguese territory, it has also the purpose of collecting data and most of all to attaining knowledge or abilities in areas where information is either limited or totally lacking in Portugal.

The aim of this Project is an integrated analysis of the main processes involved in heating and/or cooling of buildings with thermoactive geostructures systems, from the stage of soil

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Leading Institution

LNEC – National Laboratory for Civil Engineering (Portugal)

Partners

UA – University of Aveiro (Portugal), IST – Instituto Superior Técnico (Portugal)

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CERIS Research Team

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CERIS

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thermal characterization to the building's energy efficiency long term evaluation. In the present case, the behaviour of a specific building in UA campus (CICFANO) will be simulated based on data collected from the building and from its foundation soil and its sustainability accessed. Further sustainability analyses will be carried out for other cities in Portugal (different soil and climate conditions) and different building typologies.

Because energy management and climate change are major problems facing society in the XXI century, scientific studies related to the use of renewable forms of energy and means of tackling climate changes assume great importance. This research team believes that the study they intend to carry out may acquire a strategic and increased importance for the development and life standards of southern European countries, and in this specific case, of Portugal and its specific conditions. The socio-economic impact of this theme is evident.

The Project is organized in the following topics: i) laboratory thermo-mechanical soil characterization, ii) soil sampling and installation of an in depth temperature monitoring system in a building located at the UA University campus; iii) implementation and application of numerical models to evaluate and simulate the behaviour of the thermoactive geostructures system of the case study building; iv) integrated numerical analyses of the building; v) sustainability evaluation for different scenarios.

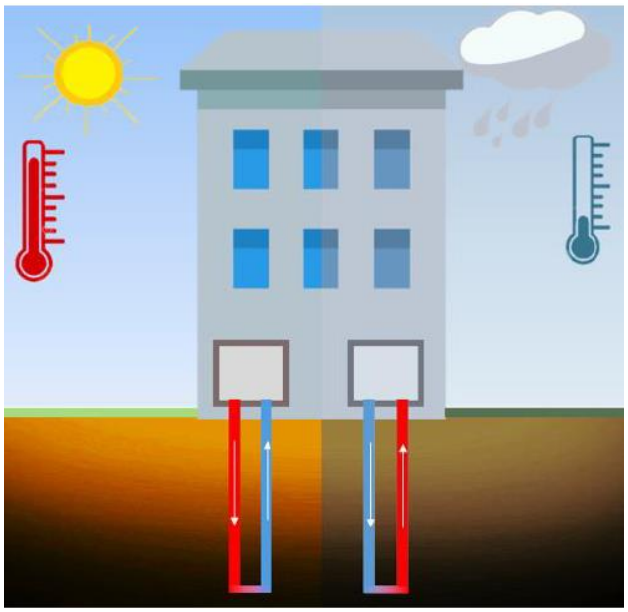

Figure 1. Overview of a Shallow geothermal system.