EGU2020-3684
https://doi.org/10.5194/egusphere-egu2020-3684
EGU General Assembly 2020

Using buildings' foundation as a GHE in moderate climates

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Shallow Geothermal Energy, a Renewable Energy Source, finds application through Ground Source Heat Pumps (GSHPs) for space heating/cooling via tubes directed into the ground. There are two main categories of Ground Heat Exchanger (GHE) types: the horizontal and the vertical types. Ground Heat Exchangers (GHEs) of various configurations, extract or reject heat into the ground. Even though GSHP have higher performance in comparison to the Air Source Heat Pumps (ASHPs), the systems high initial costs and long payback period have made it unattractive as an investment. GSHP systems can also be utilized in the buildings foundation in the form of Thermo-Active Structure (TAS) systems or Energy Geo-Structures (EGS), with applications such as energy piles, barrette piles, diaphragm walls, shallow foundations, retaining walls, embankments, and tunnel linings. Energy piles are reinforced concrete foundations with geothermal pipes, whereby the buildings foundations are utilized to provide space heating and cooling. Apart from energy piles, another EGS system can be achieved by the incorporation of the building's foundation bed as a GHE. Foundation piles are not required in all constructions, but a building's foundation bed is mandatory. This configuration is still based on the principles of the energy pile.

Energy piles have yet to be applied in Cyprus and, thus, a preliminary assessment considered and investigated before application would be useful. The potential of the GSHP systems by utilizing the building's foundation through energy piles is considered here, for a moderate climate such as Cyprus, towards a Zero Energy Building. Typical foundation piles geometry in Cyprus consists of a 10m depth, a 0.4m diameter and reinforced concrete as a grout material, which is used at the foundation bed of the building. A typical dwelling in Cyprus is selected to be numerically modelled in this study. It is a three-bedroom, two-storey house with a 190m^2 total floor area, matching the thermal characteristics of a Zero Energy Building (i.e., U-values of 0.4W/m^2/K on all walls and ceiling and 2.25 W/m^2/K on all doors and windows, respectively). A full-scale model is developed in COMSOL Multiphysics software, to examine the energy rejected or absorbed into the ground by taking the heating and cooling loads of the typical dwelling in Cyprus. The convection-diffusion equation for heat transfer is used with the three-dimensional conservation of heat transfer for an incompressible fluid on all domains except the pipes, where a simplified equation is used. Different months in winter and summer are accounted for the simulations and the fluid-in – fluid-out temperature difference is presented. Finally, an economic evaluation of the systems examined above is presented, in order to check its viability. It is concluded that utilizing the dwelling's foundations can be a better investment than using GHEs in boreholes.