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A NUMERICAL STUDY TO INVESTIGATE THE IMPACT OF PHASE CHANGE MATERIALS ON THERMAL CAISSON SYSTEMS PERFORMANCE

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ABSTRACT

Thermal caissons (TCs) are new cost-effective foundation-based energy systems that provide heating and cooling to buildings by utilizing ground-source heat pumps (GSHPs) and embedded phase change materials (PCMs). PCMs are used in TCs to improve the thermal performance of the system and help to mitigate efficiency degradation of GSHPs in buildings with large thermal imbalance. To understand the challenges and limitations associated with the application of PCMs in the context of TC systems, a complete picture of the impacts of PCM properties (e.g., thermal conductivity, solidification and melting points) on the performance of TC systems needs to be provided. The main objective of this study is to perform a preliminary assessment of such impacts based on hourly heating and cooling loads of a prototype residential building. Furthermore, sensitivity analyses are performed to understand how varying the thermophysical properties of the PCM will change the outlet fluid temperature and the overall performance of the TC systems. To achieve these objectives, in this study, a computational fluid dynamics (CFD) model is developed for a ten-meter-long TC (1.4 m in diameter and filled with concrete) consisting of four 0.15 m-diameter steel pipes (located in the inner perimeter of TC) using ANSYS Fluent. All four pipes are filled with RT2HC PCM and inside each steel pipe there is a U-loop ground heat exchanger. Working fluid (25% propylene glycol) coming from the building enters the heat exchangers which are connected in series from the top of the caisson, then returns to the building with two pipes (supply and return) connecting to a 0.5-ton heat pump. The results show that different thermophysical properties (such as thermal conductivity, melting and solidification points) of the PCM could have a substantial impact on the overall performance of TC systems. Furthermore, incorporating PCMs with higher thermal conductivity in TC systems would minimize the heat waste to the surrounding soil. It can be concluded that the use of PCM with specific and optimized properties within the TC systems can result in improved efficiency of this novel HVAC technology for buildings.