Geothermal Energy: A Renewable and Sustainable Source for Heating and Cooling Building Envelopes and De-Icing Bridge Decks

Omid Ghasemi-Fare, Ph.D., PE
Associate Professor, Civil and Environmental Engineering, University of Louisville, KY.

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Abstract

Ground Source Heat Pumps (GSHPs) provide a renewable and sustainable solution for heating and cooling building envelopes by utilizing shallow geothermal energy. Despite their benefits, the high initial cost of drilling and installation limits widespread adoption. To address this, geothermal heat exchangers are integrated with structural components such as energy piles, which serve dual purposes of foundation support and thermal exchange. This research focuses on enhancing the efficiency of geothermal piles through the development of advanced numerical and experimental models to study heat and mass transfer in saturated and unsaturated soils. These models capture the thermally induced pore fluid flow and its impact on heat transfer, particularly in permeable soils like sand. Laboratory-scale tests and soil temperature data validate the numerical predictions, providing insights into short- and long-term thermal performance under various climatic and geologic conditions. In addition to applications for building heating and cooling, several field-scale tests and numerical simulations were conducted to evaluate the performance of geothermal heated bridge decks. These studies demonstrated the effectiveness of geothermal systems in preventing ice formation on bridge decks by maintaining surface temperatures above freezing, even under extreme winter conditions. This dual application of geothermal energy enhances the safety and durability of infrastructure while offering significant environmental, economic, and social benefits. The findings from this research underscore the potential of geothermal piles as a versatile and sustainable energy solution for diverse applications, including building envelopes and bridge deck de-icing systems.

Short Bio

Dr. Ghasemi-Fare is an Associate Professor of Civil and Environmental Engineering. He has served as the PI or Co-PI on multiple projects, totaling 8.5 million dollars with a contribution exceeding 2.5 million dollars. His research has been funded by the National Science Foundation, the US Department of Transportation, Kentucky Transportation Cabinet, NSF EPSCoR at Kentucky, and CODRE. With over 75 technical articles published in esteemed journals and conference proceedings, Dr. Ghasemi-Fare's expertise spans geothermal energy, thermo-hydro-mechanical modeling, unsaturated soil, hydrometeorological hazards, microstructural analysis of soils, evapotranspiration from the bare-soil, and multiphase flow in the subsurface area.

Dr. Ghasemi-Fare has chaired and co-chaired multiple technical sessions focusing on sustainability, Multiphysics, and Multiphase Flow in Porous Media at both national and international conferences. He has also delivered numerous invited lectures at international conferences, ASCE Sustainability webinars, and ASCE annual web conferences.