Department of Civil and Environmental Engineering
Seminar Announcement

"Investigation of Coupled Heat Transfer and Water Flow in Unsaturated Soils: An Application to Soil-Borehole Thermal Energy Storage Systems"

Presented by

Dr. Tuğçe Başer
Postdoctoral Research Associate, Department of Civil and Environmental Engineering, University of Alberta, Edmonton,

Abstract:

Soil-Borehole Thermal Energy Storage (SBTES) systems are an approach to store thermal energy collected from renewable sources in the shallow subsurface. They function by direct circulation of heated fluid through closed-loop geothermal heat exchangers in closely spaced vertical borehole arrays. Despite their successful use in practice, high initial upfront costs and low efficiency necessitate further research to enhance these systems. This involves a better understanding of heat transfer mechanisms when storing and harvesting heat from SBTES systems and their implication on community resilience including the limits of extractable heat for design purposes.

Identification of an optimal location of SBTES systems in terms of the hydrogeological setting and associated thermal properties is a subject that has not been well-studied. Due to concerns about groundwater flow, an approach to potentially enhance the efficiency of SBTES systems is to install such systems in the vadose zone where the soil is unsaturated. However, investigation of SBTES systems installed in unsaturated soils requires mathematical models that consider coupled heat transfer and water flow and its effect on the thermal properties of soils. Yet, these coupled processes have not been considered when modeling of SBTES systems. Instead, most of the current models to design SBTES systems and to characterize the thermal response, rely on pure conduction with constant thermal properties.

This research explains how the coupled heat transfer and water flow processes and coupled thermo-hydraulic constitutive properties of soils may be exploited to enhance heat injection and heat retention in an array of geothermal borehole heat exchangers. To reach the objective, the tasks include: (1) constructing two field scale tests; (2) evaluating coupled heat transfer and water flow within heavily-instrumented soil tanks; (3) validating a numerical model that incorporates recently-developed coupled thermo-hydraulic constitutive relationships for unsaturated soils into a coupled heat transfer and water flow model that considers time-dependent, non-equilibrium water phase change, and enhanced vapor diffusion; (4) performing additional numerical analyses with simplified models for comparison. Overall, the results from the numerical simulations and the laboratory and field experiments confirm the good performance of SBTES system in the vadose zone, which supports

that considering coupled heat transfer and water flow when simulating the SBTES systems is crucial. The numerical tool developed in this research is currently being used in developing design guidelines and efficiency optimization of SBTES systems.

Monday, January 29, 2018
12:00 -1:00 pm
3310 Newmark