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Experimental transfer function of ground heat exchanger from thermal response tests using a deconvolution approach

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Ground-coupled heat pump systems exchange heat between a building and the surrounding ground. To simulate a ground heat exchanger (GHE), a transfer function is commonly used. This function represents the ground's capacity to exchange energy. Its use allows for the simulation of the ground's response to different heat load patterns. The heat transfer process is affected by key factors such as the ground's thermal properties and the groundwater flow. Accurate evaluation is critical for designing the GHE field to meet the thermal needs of a building for heating and cooling.

The transfer function of the GHE represents its heat transfer over a time range from seconds to years of operation. The long-term component is usually defined by an analytical model, while the short-term component requires a more complex model to be evaluated. Indeed, analytical models do not accurately represent the transient heat transfer effects that occur in the borehole materials and heat transfer fluid. To avoid using thermal transfer models, the data from a thermal response test (TRT) can be used to retrieve an experimental transfer function. This study aims to outline the different applications of a deconvolution algorithm to retrieve a short-term transfer function from experimental TRT data.

Applying a deconvolution algorithm to the outlet temperature signal of a TRT allows for estimation of the short-term response of the GHE without the need for a defined thermal model. The algorithm can iterate on the transfer function form, enabling accurate reconstruction of experimental temperature. One advantage of this method is that it only requires experimental data from a TRT to construct the transfer function.

The methodology is applied to tests with constant and varying operating conditions, allowing to obtain one or more transfer functions depending on the number of operating conditions. Additionally, a deconvolution algorithm can be utilized to interpret distributed thermal response tests, helping in the identification of geological layers with the best thermal properties. This can assist system designers to reduce drilling costs for systems with multiple boreholes. Results present transfer functions that are smooth and close to ones obtained from a more advanced numerical model. Additionally, they can reconstruct experimental temperature precisely. It is worth noting that the transfer function curve is affected by groundwater flow, with larger flows resulting in a decrease in the curve for similar operating conditions.

In conclusion, this research demonstrates the diverse applications of a deconvolution algorithm in

interpreting a thermal response test across various geological settings, groundwater flow rates, operating conditions, and types of GHE. This leads to the estimation of a short-term transfer function, which can be used either to compute thermal parameters or validate various heating loads on the GHE through implementation in a simulation algorithm.