Reto Kluser

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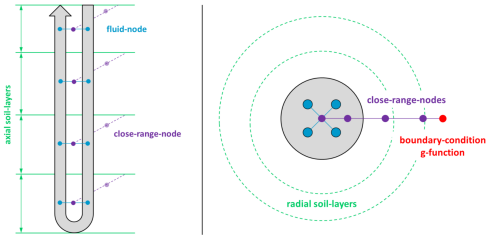
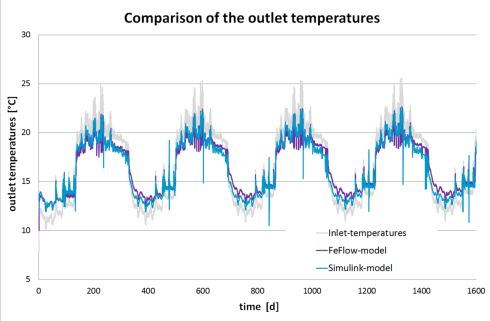
Subject Area	Environmental Engineering

Modelling and Simulation of Ground-Coupled Building Systems

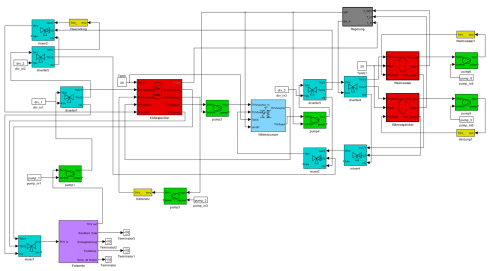
Semester project in cooperation with Gruner Roschi AG



Structure of the simplified borehole model (Left side: longitudinal section; Right side: cross-section)



Outlet temperatures of the brine compared during four years



Simplified borehole model integrated into a building system with a heat pump (light blue block) as well as storages (red blocks)

Task: For the simulation of systems with ground-coupling, detailed models are available. However, the coupling between the ground and the building system is often sophisticated which could result in long simulation time. Thus, in the frame of the project simplified modelling approaches for the simulation of the system technology, e.g. heat pumps, chillers and storage components, as well as the coupling to the ground are investigated. The objective of the project is the development of an open tool for the simulation of building systems with ground-coupling in an early design stage, where the focus is set on the design of the components for a subsequent cost estimation.

Objective: The simplified borehole model is implemented with S-functions in Simulink. An S-function is the computer language description of a dynamic system and provides a programming interface for the Simulink environment. The model includes the brine which flows in the pipes and the probe close-range as finite-difference-model with g-functions as a boundary condition of the borehole field interaction. Since double U-tube probes are the most common ground-coupled heat exchangers, only this type is considered. Furthermore, as the g-function represents the entire borehole field, only one probe has to be simulated. However, this has the restriction that only borehole fields with parallel flow can be simulated. Thus, the outlet temperature of the brine in the simulation represents a mixed temperature of all imaginary individual probes.

Result: The simplified borehole model has been validated with three other models and programs. The generated values and behaviour of the model are consistent with the data from these programs. The simulation time for a 10x10 borehole field is significantly shorter compared to the detailed simulation program, even though the devations in the simulation results are small. Afterwards, the borehole model has been successfully integrated into a simplified building system. It was connected to other system components and the interactions between these blocks has been tested subsequently. The system model can simulate five operating modes, such as freecooling as well as parallel heating and cooling. The simulation time, though, was still quite long due to the partly detailed component models. As a next step, the borehole and the system component models should be simplified to order to find a good compromise between the level of detail for the modelling and the simulation time.