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Performance Evaluation and Operation Mechanism of Deep Borehole Heat Exchanger with Different Types of Boundary Conditions

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Due to its sustainability, continuity and low carbon emissions, the utilization of geothermal energy is gaining more attention all around the world. Shallow geothermal energy is usually extracted through borehole heat exchangers (BHE) with a maximum length up to 150 m. Such systems typically require large space areas, thus limiting its application in built-up urban areas. This study presents a case where deep borehole heat exchanger (DBHE) with a depth down to 2500 m was constructed to extract geothermal energy for building heating purposes. A double-continuum finite element based numerical model was set up to simulate the heat transport process within and around the DBHE. The model has been validated by the experimental data in a demonstration project located in Fengxi, Xi'an China. The heat extracting performance of DBHE under different types of boundary conditions (including the Dirichlet condition and Neumann condition) are evaluated. The amount of thermal recharges from top, sides and bottom of the domain were differentiated and quantified. It is found that different types of boundary conditions will lead to deviations in the simulated heat fluxes and corresponding thermal recharge. The numerical simulations also suggest that the sustainable heat extract capacity of DBHE is mainly determined by the stored heat from the surrounding subsurface, and thermal recharge takes only a limited contribution. According to the calibrated modelling results, the proper heat extraction rate of DBHE in the long-period operation modes is analyzed.