The Potential Study of Open Loop System Geothermal Heat Pump in Gifu City, Japan

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Geothermal heat pumps (GHPs) are considered to be one of the most energy efficient and environmentally friendly air-conditioning systems for temperate zones. In Japan, the expansive use of GHPs technology is finite, because of insufficient information on the advantages offered by the system and high installation cost. Therefore, the prediction of potential energy of GHPs at the first stage of installation is desirable. Open-loop system is one of GHPs types system which mostly depends on geological and hydrogeological parameter. This system interacts directly with ground and groundwater factor, because it uses groundwater as direct heat transfer medium through extraction and injection wells. Accordingly, groundwater flow with heat transfer is the most important factor that could affect the performance of open-loop GHPs system. Therefore groundwater flow system as well as distribution of subsurface temperature must be comprehended in detail. The aim of this study is to understand the distribution of groundwater flow and heat transport in study area from the simulation study using the program, FEFLOW. FEFLOW is a finite element code which can numerically simulate groundwater flow and heat transport. As the final result, the simulation model can be used to understand of open loop GHPs system in specified area.

The study area is an alluvial fan of the Nagara River, Gifu city, Japan. It is bounded by mountain ranges from north to northeast side and plain area remains. The Nagara River flows in the center of the plain. This alluvial fan is composed of sands and gravels and often intercalate thin fine sand and silt layers. Groundwater flow occur mainly in the Quaternary deposits, which are sand and gravel layers. Alluvial fans are recharge areas of groundwater and rapid groundwater flow are expected. The underground temperature in alluvial fan is affected by rapid groundwater flow recharged from a river. For assessment of potential energy of open loop GHPs, 3D model of groundwater flow with heat transport in Gifu city was developed using FEFLOW program. Model is constructed first by geological and hydrogeological data. The pre-existing geological columns and profile of study area were collected, which consisted of borehole and cross section data. Furthermore, pre-existing hydrogeological data which consist of groundwater table, underground temperature, and temperature of river water data in study area are also compiled to construct the simulation model. Boundary condition of groundwater flow system is defined by water table distribution. Bottom of the model is basement rock, treated as impermeable boundary and lateral sides are set as no flow boundaries. For boundary conditions of heat transport, top and bottom of the model are fixed by constant temperature boundaries, and lateral sides are as insulated. Based on constructed model, the simulation on groundwater flow with heat transport is performed. The effectiveness of heat transport and fluid flow are affected by material properties. Material properties were determined on the basis of formation types. Groundwater temperature were matched against observed temperatures, using the result of groundwater flow simulation. The observed underground temperatures in study area are fluctuated not only near surface but also in aquifer. This temperature change is resulted from lateral flow of the recharged groundwater. The calculated groundwater temperature will be adjusted until simulation result agreed with observed data from field. So that model can represent the groundwater flow system in alluvial fan of the Nagara River, Gifu city, Japan. For future plan, simulation model is used to investigate potential open loop GHPs system resulted from presence flowing groundwater in study area. This

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simulation model is effective to predict the natural change of underground temperature, one main factor that affecting heat pumps efficiency.

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