Japan Geoscience Union Meeting 2015
(May 24th - 28th at Makuhari, Chiba, Japan)

AHW26-P09 会場:コンベンションホール 時間:5 月 27 日 18:15-19:30

広域における地中熱ポテンシャル評価のための地下水流動系の解析
Analysis of groundwater flow system for potential assessment of ground-source heat pump system in regional scale

シュレスタ ガウラブ[1*] ; 内田 洋平[1] ; 吉岡 真弓[1]
SHRESTHA, Gaurav[1*] ; UCHIDA, Youhei[1] ; YOSHIOKA, Mayumi[1]

[1]（独）産業技術総合研究所
[1]National Institute of Advanced Industrial Science and Technology

Ground-source heat pump system is an energy efficient and environment friendly technology that utilizes natural heat stored in a subsurface of shallow depth up to about 100m. It is used for space-heating, space-cooling, hot water supply and snow-melting purposes. Development rate of GSHP system is gradually increasing in Japan. However, the pace is still lacking behind America and European countries because of higher initial cost resulted by oversized design of ground heat exchangers (GHE) and lack of information on its advantages. To promote the development of GSHP system, evaluation of suitable locations for its installation is essential.

Regarding geology, Quaternary System usually exists in the shallow subsurface which mainly consists of sand and gravel. In this Quaternary System, groundwater is actively flowing. For this reason, hydrological and geological information are necessary because they largely influence the subsurface temperature distribution, and consequently affects heat exchange rate of GHE as well as overall operation of GSHP system.

In this study, groundwater flow system of the Tsugaru Plain in Aomori Prefecture was comprehended in order to assess the potentiality of GSHP system. A regional scale 3D groundwater flow ? heat transport model was developed for this purpose. Horizontal dimensions of the model were 64km in east-west and 78km in north-south direction. In the model, layers 1 ? 4 belonged to Quaternary System, layers 5 ? 7 to Neogene and layers 8 ? 12 to Paleogene. Saturated steady state simulation of groundwater flow and heat transport was conducted with this model. In Tsugaru Plain, hydrological field data such as groundwater level could not be measured as groundwater observation wells were not sufficient. Therefore, the analysis model was verified by comparing the computed hydraulic heads and water table with past studies and literature values. Additionally, computed results were validated by inspecting the path of simulated groundwater flow at natural springs, confirming if groundwater was flowing in upward direction.

Based on the simulation results of the analysis model, distribution maps of groundwater flow velocity, water table depth from subsurface and subsurface temperature were prepared using geographic information system (GIS). Groundwater flow velocity was found higher at peripheral areas. It can be due to higher hydraulic gradient near the mountainous areas. At areas with higher groundwater flow velocity, improved heat exchange rates of GHEs can be expected because of advection effect. Water table depth from surface was found to be shallow in most of the areas of the plain, which indicates the sustainable operation of GSHP system from the view point of groundwater availability and saturation of geological layers. Aomori Prefecture (2011) and Machida and Yasukawa (2008) showed similar results of water table. Subsurface temperature computed from heat transport simulation was found higher at the central area of plain, which is thought to be due to the heat transfer by groundwater advection. For space-heating with GSHP system, the central area can be suitable from temperature perspective. In this way, the comprehension of regional scale groundwater flow system accompanied with subsurface temperature distribution can provide useful information to assess suitable locations for the installation of GSHP system.

References:

Aomori Prefecture (2011) Survey report on potential use of ground-coupled heat pump system and hot spring temperature in Aomori Prefecture. Aomori, Japan, 210 pp (in Japanese).

Machida, I., Yasukawa, K. (2008) Regional groundwater survey for the use of GSHP system in Aomori Prefecture. Vision for the promotion of GSHP system in Aomori Prefecture, Aomori, Japan, pp. 91-126 (in Japanese).

Keywords: ground-source heat pump system, groundwater flow, heat transport, potential assessment