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Ground Source Heat Pump Research in South Korea

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ABSTRACT

An experimental ground source heat pump plant has been installed in 2003 in the city of Daejon, South Korea, in a German-Korean co-operation. Different types of borehole heat exchangers (BHE) with different types of thermally enhanced grout are investigated under controlled circumstances, allowing a comparison. The tests are complemented with the determination of underground thermal parameters using the first thermal response test equipment built in Korea.

On the heat pump side, an innovative concept with the inclusion of an ice storage system is used, in order to allow the use of cheap night-time electricity for cold production in summer. The plant is purely for R&D-purposes, however, different components already have been applied successfully on the market.

The paper describes the layout of the test plant as well as the results achieved meanwhile.

INTRODUCTION

Since some years contacts exist between German and Korean researchers through the Energy Storage Programme of the International Energy Agency IEA. The Korean partner is the Korean Electric Power Research Institute KEPRI, situated in the "science city" Daejon in the centre of South Korea and working with development of heat pumps and ice storage in order to allow air conditioning be run by cheaper night-time electricity and to shave the demand peaks during summer days.

A co-operation was started to install an experimental borehole heat exchanger (BHE) plant on the KEPRI premises to gain experience and to prepare the construction of large ground source heat pump (GSHP) plants for heating and cooling.

SITE CONDITIONS

The construction of the experimental plant was done in spring 2003 by HP System Tech, a spin-off company of KEPRI, on the premises of the research institute. The German companies UBeG in Wetzlar and EWS Erdwärme-Systemtechnik in Delbrück provided the necessary knowledge and experience and shipped key components to Korea.

The underground at the KEPRI-site consists of paleozoic mica-shists (fig. 2). Looking at all of Korea, rocks from almost all of the earth history can be found, frequently metamorphous or crystalline (mainly in the northern and central region), but also sediments from paleozoic up to tertiary age (in the southwest). The ground conditions in Korea thus can vary widely, with some large population centres like the capital Seoul being located in the crystalline area.

The mica-shist as found in Daejon can be drilled without problems (using a down-hole-hammer), the holes are stable, and the thermal properties of the underground rather good. A thermal response test rig, built in Korea following a German prototype (UBeG), was used to measure ground thermal conductivity. In all three boreholes values well above 3.0 W/m/K were detected (table 1).

Figure 1: Outcrop of mica-shist ca. 200 m from the experimental plant (above, photo Sanner) and rock sample (below, photo Schorge)

Table 1: Ground thermal conductivity measured with Thermal Response Test

Type of BHE	Thermal conductivity
BHE1 (German double)	λ = 3,25 W/m/K
BHE2 (German single)	λ = 3,50 W/m/K
BHE3 (Korean double)	λ = 3,23 W/m/K

INSTALLATION OF THE BHE IN SPRING 2003

In spring 2003 the pre-fabricated BHE (HAKA, Switzerland), the manifold and the thermally enhanced grout have been shipped to Korea. (fig. 2). This shipment was just done for the test plant, later on the material will all be produced in Korea. In April 2003 four boreholes have

been drilled down to 100 m (fig. 3), and end of April the BHE were installed and grouted, with assistance from Germany (fig. 4).

Figure 2: German grouting material and Swiss pre-fabricated BHE on site in Daejon, April 2003 (photo Sanner)

Figure 3: Drilling on the KEPRI site in April 2003 (photo Choi)

Figure 4: BHE pipe installation in April 2003 using a makeshift roller device (photo Sanner)

The following BHE were installed in the 4 test boreholes:

- BHE1 (German double), double-U-tube from HAKA
- BHE 2 (German single), single-U-tube from HAKA
- BHE 3 (Korean double), double-U-tube manufactured in Korea
- BHE 4, only drilling yet, is intended as a reserve.

All BHE have been grouted with thermally enhanced grout provided by EWS.

The values for borehole thermal resistance have been measured with the Thermal Response Test prior to the first heat pump operation. These values for double-U-pipes (table 2) are below r_b = 0,1 K/(W/m) and thus in the range theoretically determined and in Germany also measured frequently (Sanner et al., 2003). The single-U-pipe has naturally a higher borehole thermal resistance. The values correspond nicely with the theoretical values of r_b = 0,075 K/W/m for a double-U-tube and r_b = 0,112 K/W/m for a single-U-tube, respectively, with a grout thermal conductivity of λ = 1,6 W/m/K.

Table 2: Borehole thermal resistance measured with Thermal Response Test

Type of BHE	Borehole thermal resistance
BHE1 (German double)	r_b = 0,07 K/(W/m)
BHE2 (German single)	r_b = 0,11 K/(W/m)
BHE3 (Korean double)	r_b = 0,08 K/(W/m)

HEAT PUMP AND ICE STORAGE

In summer 2003 at the BHE test site a heat pump with ice storage, developed by KEPRI and HP System Tech, has been installed and connected to the BHE circuit. Fig. 5 shows the test heat pump located outdoors between the HP System Tech building and the BHE field. The heat pump setup contains two large storage tanks (warm water and ice) with the heat pump located in between. The three existing BHE can be connected to the evaporator (heating mode) as well as to the condensor (Cooling mode), individually or all together. The storage tanks allow for test operation in both directions independently of consumers, however, the heat pump is linked to the building and can also cover heating and cooling loads.

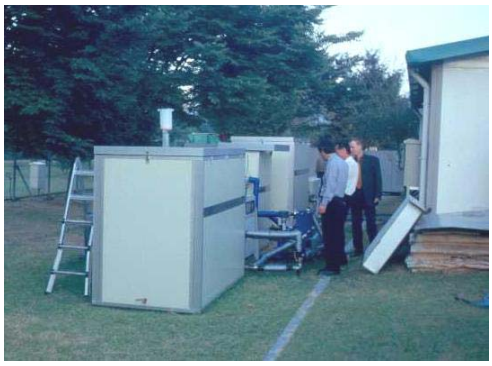

Figure 5: Experimental heat pump made by HP System Tech, with hot water- and ice-storage tanks (photo Sanner, Oct. 2003)

The combination of the specific HP System Tech ice storage technology with BHE as heat source and sink promises very good economy in particular in cooling mode. The geographical situation of Korea with warm and humid summers creates such a need for cooling.

Meanwhile other suggestions from Germany have been implemented, e.g. a reel for the BHE installation to replace the makeshift-roller seen in fig. 4.

REFERENCES

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