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In situ experiments on the performance of near-field for nuclear waste repository at KURT

Won-Jin Cho[a,*], Jin-Sub Kim[a], Changsoo Lee[a], Sangki Kwon[b], Jong-Won Choi[a]

[a] *Korea Atomic Energy Research Institute, P.O. Box 105, Yuseong, Daejeon 305-600, Republic of Korea*
[b] *Inha University, Department of Energy Resources Engineering, 253 Yonghyun-dong, Nam-gu, Incheon 402-751, Republic of Korea*

HIGHLIGHTS

- Results of in situ experiments on the near-field of a repository are summarized.
- In BHT, the rock temperatures at 0.3 m from heater showed 40–50 °C increase.
- EDZ size measured from the in situ test was in the range of 0.6–1.8 m.
- Maximum errors in estimating the location of AE source were 0.6–1.0 m.
- Permeability in the EDZ increased up to 2 orders compared with the intact rock.

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ABSTRACT

To obtain the information on the design and performance assessment of a geological repository for nuclear waste, several in situ experiments on the performance of the near-field have been conducted for 5 years in the small-scale underground research laboratory, KURT. This paper summarizes the results from the in situ experiments. In the borehole heater test, the rock temperature at 0.3 m distance from the heater hole with 90 °C showed a 40 °C increase over initial temperature. After heating with 120 °C, the rock temperature at 0.3 m distance from the heater hole increased up to 50 °C over initial temperature. The EDZ size measured from the in situ test was in the range of 0.6–1.8 m, and was higher than that from the laboratory tests, which was estimated to be around 1.1–1.5 m. The maximum errors in estimating the location of acoustic emission source were 1.0 m in EDZ and 0.6 m in an intact rock zone, respectively. The damping ratios of the EDZ and intact rock were 0.091 and 0.005, respectively. The permeability of rock increased with decreasing distance from the tunnel wall because of the EDZ. The permeability in the EDZ seems to be increased up to 2 orders compared with that in the intact rock.

1. Introduction

In Korea, a total of 21 nuclear power plants, 4 CANDU PHWR reactors, and 17 PWR reactors are in operation as of December 2011. The nuclear power plants provide about 34% of the total electricity capacity in Korea. Seven additional nuclear power plants are planned to be constructed by 2020, and the total number of nuclear power plants will then be 28 (MOCIE, 2006). The total generation capacity of the nuclear power plants is expected to be 27,320 MW_e, and their share of electricity production will be increased to about 43% in 2020. The promotion of the nuclear energy program will inevitably result in the generation of a significant amount of nuclear waste. The safe isolation of nuclear waste from the human environment and the biosphere is a critical issue to maintain the continuing growth of nuclear energy. The geological repository has been considered as a most probable option to protect the public health and the environment from the radiological effects due to nuclear waste for its harmful period.

The geological repository would be constructed in a bedrock at the depth of several hundred meters below ground surface. The repository in Korea would be expected to be of a room-and-pillar design. The nuclear waste packed in a canister would be deposited in an array of large-diameter boreholes drilled on the floors of disposal rooms (Choi et al., 2008). The near-field rock controls the dissipation of decay heat from the waste to the surrounding environment, and plays an important role to determine the temperature distribution in the repository. As the performance of the repository can be affected by temperature, there are various limits of peak temperature for the geological repository. Therefore temperature distribution acts as a constraint on the design of a geological repository because it restricts the amount of nuclear waste to be disposed in any given area of the repository. The near-field rock has also a

* Corresponding author. Tel.: +82 42 868 2852; fax: +82 42 868 8850.
E-mail address: wjcho@kaeri.re.kr (W.-J. Cho).

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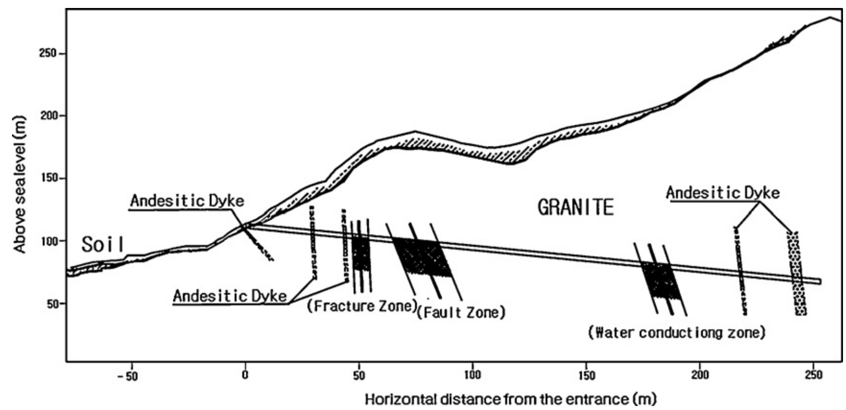

Fig. 1. Geological conditions of the KURT site.

significant influence on the groundwater flow around the repository. The blasting of rock during the construction of underground tunnel produces the generation of micro fracture in the rock, and the presence of fracture in the near-field rock can provide the possible pathway for radionuclide release to the environment. Therefore the evaluation of the performance of near-field rock is important for the design and radiological assessment of a nuclear waste repository. To evaluate the performance of near-field, it is required to investigate experimentally thermal and mechanical behavior of the rock under the underground condition. Therefore, the in situ experiments at the underground research laboratory are the matters of great importance to the improvement of public acceptance on the safety of nuclear waste disposal. The KURT (KAERI Underground Research Tunnel) is a small scale generic underground research laboratory constructed in the Korea Atomic Energy Research Institute (KAERI) territory (Cho et al., 2008), and its operation was started in November 2006. KURT has provided the opportunities for the research on nuclear waste disposal in typical Korean geological environment. The experience and knowledge gained from the in situ experiments at the KURT will make an important contribution to implement the commercial geological repository program successfully in future.

In this paper, the in situ experiments on the near-field performance that have been carried out for past 5 years at KURT are summarized, and their results are also analyzed.

2. Overview of the KURT

KURT (KAERI Underground Research Tunnel) is located at a mountainous area in the site of the Korea Atomic Energy Research Institute (KAERI). The geological conditions around KURT were reported by Cho et al. (2008) and Kwon et al. (2006). The major rock type at the KURT site is granite. Around the site, the residual weathered soils from the granitic rock, and the silty sand containing rock fragment cover the ground surface. Underneath them, the weathered rocks are distributed. The average thickness of the weathered layer was 5–15 m. The soft rock, the normal rock, and the hard rock are distributed below the weathered layer.

Along the access tunnel of KURT, the weathered soil was distributed to 4 m from the entrance. Below the weathered soil layer, a 10 m thick weathered rock layer and 14 m thick weak rock layer are laid. Afterwards, hard rock continues up to 250 m. At the five locations, 28 m, 47 m, 118 m, 124 m, and 235 m from the entrance, 1–3 m wide andesite dikes were encountered. Observable

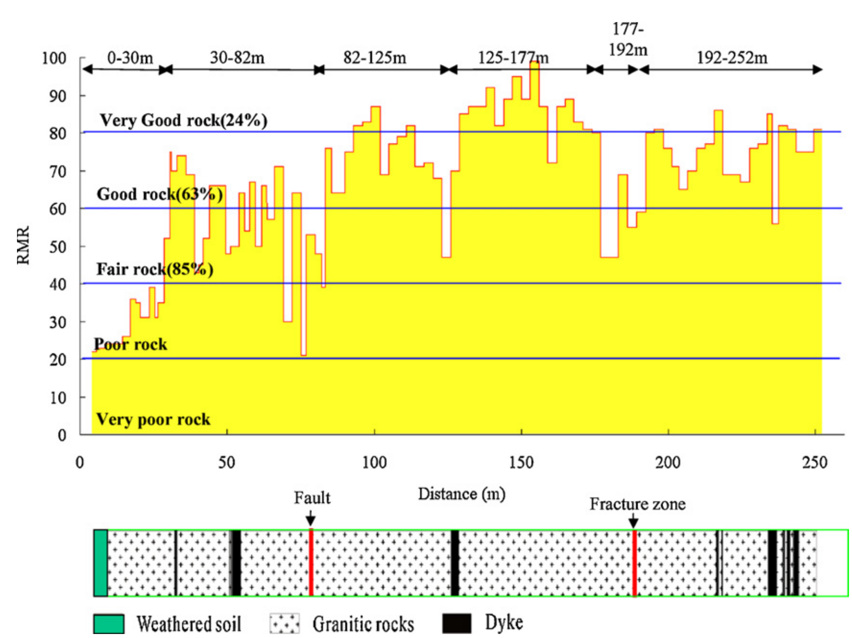

Fig. 2. Variation of the RMR along the declined borehole.