KAERI Underground Research Tunnel (KURT) - Phase II Activities for HLW Disposal Technology Development in Korea – 15253

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ABSTRACT

Phase I construction of the KAERI Underground Research Tunnel (KURT), a small-scaled underground research facility, was completed in November 2006. Since then various in-situ tests and experiments at KURT for phase I have been carried out to develop safe and reliable disposal techniques for high-level radioactive waste in a deep geological formation. The KURT extension project was approved by the Korean government in 2012 and the design of the tunnel layout and construction methods were decided by early 2013. Site investigation and installation of a monitoring system for the extension were completed by Oct. 2013. The construction activity was started from December 2013 and will be completed by the end of 2014. Phase II experiments in KURT will be carried out for the next 10 years. KURT continues to play a significant role in validating the safety and feasibility of a deep geological disposal system in the research program in Korea.

INTRODUCTION

The Korea Atomic Energy Research Institute (KAERI) has advanced a disposal concept and its related technologies for deep geological disposal of spent nuclear fuel since 1997. KAERI is currently developing a deep geological disposal system for an HLW from the pyro-processing of PWR spent nuclear fuel. The core aim of KAERI research is to characterize the geological media, design a repository system, and assess the safety of a disposal system. To dispose of high-level radioactive waste (HLW) safely in geological formations, it is necessary to assess the feasibility, safety, appropriateness, and stability of the disposal concept at an underground research laboratory (URL) constructed in the same geological formation as the desired host rock.

For the feasibility, stability, and safety of the proposed HLW disposal concept in Korea, it was necessary to experimentally investigate the disposal system in underground conditions beginning in late 2002. In 2003, the Planning Committee for the Korean Nuclear Energy R&D Programme decided to construct a small-scale generic underground research facility at the KAERI site to test the disposal concept and relevant technologies. The KAERI Underground Research Tunnel (KURT) was constructed in November 2006, and various in-situ tests and experiments have been carried out since 2007. The KURT is a generic URL and not potential site for waste disposal. The main geology of KURT site is crystalline rock such as granite and it is not allowed to conduct any experiments using radioactive nuclides in the KURT. At present, KAERI is performing phase II programme including KURT extension work. In this paper, the role of KURT for the HLW disposal technology development in Korea and ongoing and future activities are described.

THE CURRENT STATUS OF KURT

KURT is located in a mountainous area at KAERI, Daejeon city, which is approximately 150 km south of Seoul. The host rock is two-mica granite, which is considered a potential host rock type for a HLW disposal repository in Korea. The site characterization and detailed design for the construction of KURT

were completed in 2004 [1]. Construction started in March 2005 and was completed in November 2006. KURT has a total length of 255 m with a 180 m long access tunnel, and two research modules with a total length of 75 m (Fig. 1). The maximum depth of the tunnel is 90 m from the peak of a mountain located above the site. The horseshoe-shaped tunnel section is 6 m wide and 6 m high.

There were several design requirements for construction of KURT [2].

- The long-term stability of the tunnel should be ensured with minimum rock support.
- Damage to the host rock from an excavation should be minimized.
- The access tunnel should be linear to obtain the maximum overburden of the research modules with the minimum length of the access tunnel.
- The research modules should be located at the rock mass with good quality.
- The research modules should be located in the bed rock with a fresh overburden with a minimum thickness of 50 m.
- Construction should be as economical as possible.

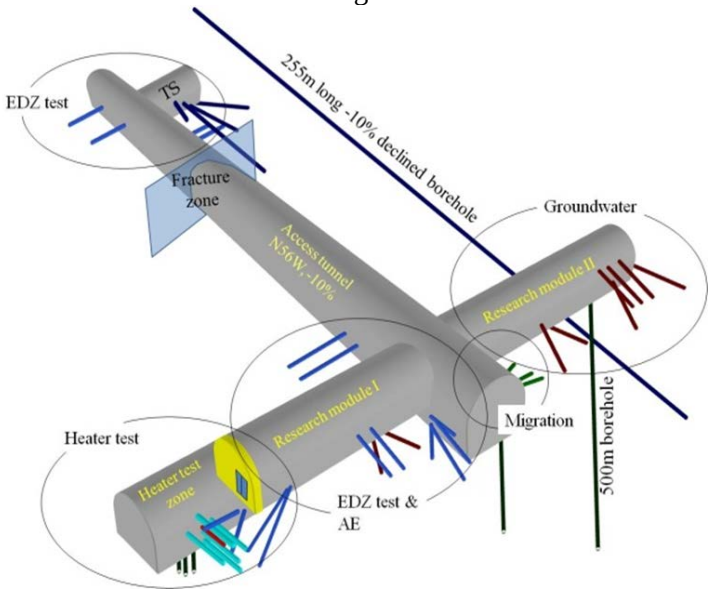

Fig. 1. Layout of the KURT and Location of Experiments

The drill and blasting method was applied to make a horseshoe shaped access tunnel and research modules. A careful blasting to minimize the blasting impact on the research reactor and other neighboring buildings at KAERI was required. Daily excavation was advanced about 1–3 m depending on the rock quality. The tunnel was supported mainly by using rock bolts and shotcrete in some zones of the tunnel. Lattice girders were installed at weak zones around the tunnel entrance and the fracture zones [2].

During phase I (2007–2012), several representative in-situ tests and experiments focused on the following items.

- Single hole heater test: A 5 kw heater was installed in a heater hole, and about 100 temperature sensors were installed inside the rock surrounding the heater. The heater temperature was controlled to be increased step by step to 90oC. The power input, heater, air and rock temperatures, rock displacement, and rock stress were measured to investigate the thermo-mechanical response of the rock mass during the heating phase.
- EDZ characterization: The rock mass properties were measured to determine the characteristics of EDZ. The rock cores collected before and after the excavation were used to compare the thermal and mechanical property changes. Different geophysical tests were also applied to determine the EDZ size.
- Solute migration experiment: The characteristics of solute retardation by the filling minerals in the rock fractures were investigated to improve the understanding of the transport and retention of solute/colloid in a fractured rock mass.
- Development of site investigation techniques: Deep geological survey techniques, as well as a QA procedure for various borehole tests, were revised to enhance the data quality.
- Hydrogeological and geochemical study: The baseline data of hydrogeological and geochemical conditions are necessary for different in situ experiments at KURT. Long-term monitoring of the hydrogeological and geochemical parameters, and an update of the site descriptive hydro-structural

model, has been carried out.

- International research projects: By the request of Sandia National Laboratories of USA, in 2011, KAERI investigated the influence of groundwater pressure on the fracture aperture size, which controls the fracture transmissivity. Additional research, i.e., a spontaneous potential experiment, is in progress to determine the hydraulic properties and behavior of the 3D subsurface volume of the saturated fractured rock using a hydraulic head and streaming potential data.

In addition to the in-situ tests, more than 1,400 people visit the KURT each year and KURT has played an important role to promote understanding of public and stakeholders.

PHASE II PROJECT OF KURT

Tunnel Extension

KAERI obtained government approval on a 5-year R&D programme for HLW long-term management system development in March 2012, which focuses on an enhancement of the performance of EBS of up to 20%, the establishment of the infrastructure for in-situ demonstrations at KURT, and the development of safety cases based on the KURT environment. During phase II (2012–2016), intensive experiments on the hydro-geological characterization of MWCF and in situ long-term performance tests on the 1/3 scale engineered barrier system are major experimental research items to be executed at the KURT facility. The current dimensions of the research modules are limited, and thus the KURT facility needs to be extended for the execution of the planned tests and experiments during phase II.

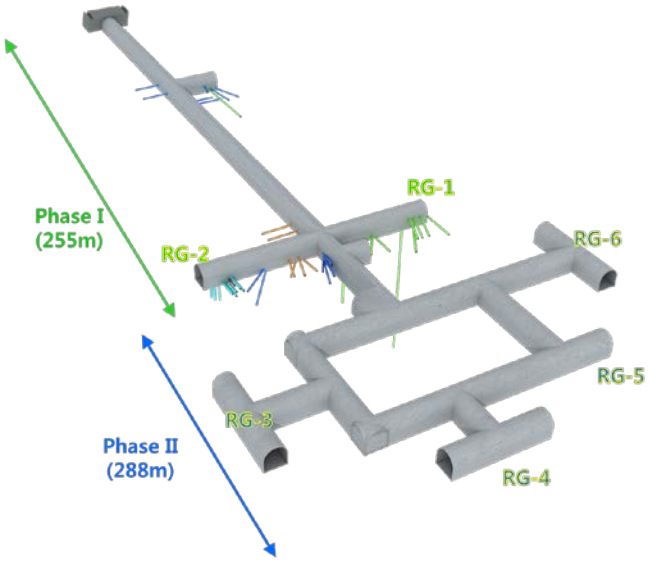

Fig. 2. Layout of Phase II KURT

There were also several design requirements for the phase II construction of KURT.

- Site investigation should be focused on the possible extension area.
- Predictive geological and rock mechanical model should be presented to ensure the extension concept.
- Extension tunnel layout should be optimized depending on the geological condition, especially distribution characteristics of WCF.
- At least, 6 research modules should be constructed within limited extension area on condition of minimizing the interference effect between adjacent research modules.

The design of the tunnel layout and construction method was optimized based on the design requirements and the results of site investigation by early 2013. Fig 2 shows a whole tunnel layout with extended area. The construction of tunnel and additional utilities was started from 2013 and completed in the end of 2014. After the construction, the total length of KURT became 543 m with 6 research modules and the maximum depth became about 120 m from the surface. In addition to the construction work, KAERI is making a long-term development plan of the KURT facility to achieve the practical and effective

utilization of KURT for the development of radioactive waste disposal techniques in Korea.

Phase II Programme

To fulfill the 5-year R&D programme for HLW long-term management system development, KAERI has identified the in situ tests and experiments of phase II at KURT (TABLE I). Groundwater monitoring is the basic activity during facility operation. The very long-term corrosion experiment of a waste disposal canister using in situ deep groundwater will last until the late 2010s. The site-descriptive hydro-structural model will also be revised depending on the level of understanding of the site characteristics. MWCF studies will start during the site investigation and design stage, and a characterization of the transportation properties will follow. The design and preparation for 1/3 scale EBS performance tests were initiated in 2013, and in situ performance tests will be started from early 2015. In addition to the planned works during phase I and II, KAERI and UFDC (Used Fuel Disposition Campaign) of Sandia National Laboratories have been performing collaboration research works at KURT since FY 2013.

TABLE I. Planned In-situ Tests and Experiments

Area	Experiment	RGs		Period (yr)					
		I	II	12	13	14	15	16	17~21
Geoscience	Geological investigation	-	-						
	Site Descriptive Modeling	-	-						
	Long-term groundwater monitoring	RG-1	RG-3						
NBS	Hydrogeological properties of MWCF	RG-1							
	Transport properties of MWCF	RG-1							
	Geochemical behavior of Redox front along MWCF	RG-1							
	Pseudo-radionuclide sorption & diffusion experiment	-	RG-4						
EBS	Very long-term corrosion experiment	RG-1	RG-1						
	Preliminary performance test of EBS (KURT-LOT)	RG-2	RG-2						
	Long-term performance test of 1/3 scale A-EBS (In-DEBS-KURT)		RG-5						
	EDZ characterization	RG-2	RG-6						
Int. Col.	KAERI-SNL(UFDC) Collaboration Project	RG-1							

CONCLUSIONS

For the development of safe and reliable disposal techniques for high-level radioactive waste in a geological formation, KAERI has been performing various experimental studies at KURT to test their feasibility, safety, stability, and appropriateness. A tunnel extension was completed in 2014 and the phase II experiments will be started from 2015 in the extended KURT. Long-term experimental research programme at KURT has been prepared for the phase II KURT project and the research experiences gained using KURT will provide important information to validate the safety and feasibility of the deep disposal system and making an important contribution to the successful implementation of a geological

repository programme in the future.

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