High Speed Boreshear Tests of an Engineered Barrier System for High Level Waste Disposal

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1. Introduction

Korean peninsula is not completely free of seismic activity, since it is near to the active volcano belt of the Pacific Rim. Recently, in 2016, there was a fairly strong earthquake around Gyeong-Ju Province. To cope with such seismic influences on the disposed canister in a underground borehole, some foreign organizations in Japan (JAEA) and Sweden (SKB) have been investigating the effects of seismic movement on the underground repository for many years [1, 2]. In Korea, KAERI has also been studying seismic influence on an underground repository.

The countries which are concerned about fault movements at a repository have established the allowed conditions for fault movement in their canister design, which are summarized in Table 1. The disposal canister must not be ruptured by fault movement.

Table 1. The maximum allowed conditions for fault movement for a disposal canister

	Korea (KAERI)	Japan (JAEA)	Sweden (SKB)
Fault Velocity		1 m/sec	
Fault movement	10 cm	10 cm	5cm

It is difficult to conduct boreshear testing of a disposal canister in real scale to determine whether it can resist the expected magnitude of a fault movement crossing a borehole. Thus the testing is generally conducted at a reduced scale, to try and simulate the behavior using computational modeling, to develop a reliable evaluation tool. KAERI has also tried this approach since 2010, and created a 1/30 scale miniature boreshear testing module.

However the maximum test speeds of fault module in laboratories were much below than the requirement limit of 1.0 m/sec so far as described in Table 2. Thus the high speed boreshear module was designed, and its performance was tested at above 1m/sec experimentally in this study.

Table 2. Comparison of KAERI shear module with those of JAEA [1] and SKB [3] (Unit: mm)

Org./Scale	Canister	Hole size	Test condition
KAERI 1 : 30	D30, L60	D76, L124 t3.0(1㎛), t1.5(10㎛)	Disp. 20 SR(Shear rate) 100 ㎜/min
JAEA 1 : 20	D50, L100	D150, L350	Disp. 70, 40 SR 10, 100 ㎜/sec
SKB 1 : 10	D80, L450	D158, L622 t20 (max 12㎛) CylinderFilter L300x2	Disp. 28, 30, 21 SR 20, 100, 1000 ㎜/min

2. Module Design

Two shear modules were made at 1/30 scale of the A-KRS [4]. A module was composed of two cylindrical half parts, which can slip into each other. And the inner space diameter was 70 mm with a length of 120 mm, in which a copper rod (D30 x L60) was placed with compact bentonite blocks. There were 6 stress sensors around the module boundary of the stationary part to measure stress changes in the bentonite buffer when a shearing occurs.

A high speed shearing was achieved by punching down the other movable part with a free dropping of 97 kg mass above 20 cm high position as shown in Fig. 1. The impact velocity of the mass was about 2.0 m/sec, and it has a 196.2 J of kinetic energy.

For the water saturation of bentonite buffer, KURT underground water was supplied with 2.0 MPa pressure, and the supplied amount was monitored to know the degree of saturation. The test modules were placed in mini-environmental chambers to control them at 30˚C.

Two kinds of bentonite buffers were used in this experiments, which were pure Gyeong-Ju bentonite and the 3wt% graphite added one. Those were compacted to be 1.6 g/cm^3 in dry density.

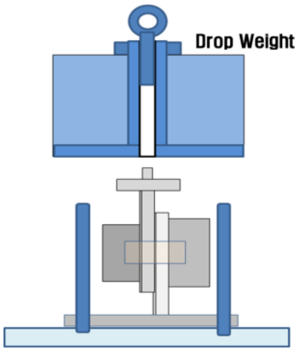

Fig. 1. Schematic drawing of a high speed boreshear test module.

Fig. 3. Shear rotated copper rod in a pure bentonite and a 3 wt% graphite added bentonite.

3. Experiment

After reaching the equilibrium of water supply, a heavy mass was dropped onto the shear module above 20 cm high. The shear displacement by the first drop was approximately 2~3 mm in two modules, which was much lower than expected. Thus more free drops were repeated 3~4 times to reach a 19 mm shear displacement.

The stress increases around shear module were suggested for 3wt% graphite bentonite buffer in Fig. 2. The maximum stress increase was about 2 MPa at bottom position near the shear plane. And the total stress increase after 19 mm shear displacement was below 5 MPa. After the test, the copper rod was examined to know if any shear deformation was occurred on it, but no deformation was observed.

The rotational angle of a copper rod was measured after dismantling of them. The rotational angle by the 19 mm shear displacement was about 23~24˚, which was a bit higher than 18˚ of a theoretical angle as shown in Fig. 3.

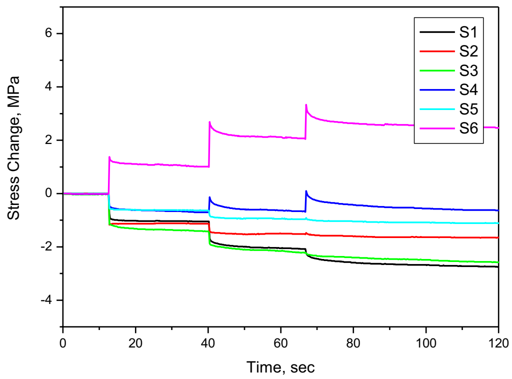

Fig. 2. The increase of shear stress by several free drops of heavy mass for 3wt% graphite bentonite.

4. Conclusion

High speed boreshear tests were performed above 1.0 m/sec velocity at 1/30 scale of A-KRS. The stress increase in the buffer was not higher than 5.0 MPa after 19 mm shear displacement. Thus it was concluded that the saturated bentonite buffer can reduce the mechanical impact by a fault movement to a moderate level not to damage the inner canister. However, the development of simulation model was needed for the clear evaluation of the full-scale boreshear safety of a disposal canister.

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