Mechanical Stress Analysis on the Disposal Container and the Solidified Wastes of the Gyeongju LILW Repository

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1. Introduction

The first stage Low-Intermediate Level Waste (LILW) repository in Gyeongju has been operated since 2015. The silos in the repository with a height of about 50 m are located 130 m below from the sea level. In the silo, about 30 concrete disposal containers containing 16 radioactive waste drums are going to be stacked up. To withstand the loads applied to the waste by other wastes and crushed rocks, the waste disposed of should have enough mechanical strength. The compressive strength criteria of the Gyeongju repository are 3.44 MPa (500 psi) for a hard solidified waste and 0.41 MPa (60 psi) for a soft solidified waste respectively. However, the criteria are almost equivalent to those of a U.S. Nuclear Regulatory Commission (NRC) report describing waste acceptance criteria for a trench type repository [1, 2]. The trench type repository referred by the report has generally a depth of 20 m, and the stacked waste would be about 10 drums [4]. The expected load applied to each disposed drums in the trench type repository will be much lower than the Gyeongju repository. Therefore, it would be required to evaluate whether the current compressive strength criteria of the Gyeongju repository are enough to prevent the damage of the solidified waste. In this study, the mechanical stress on the solidified waste placed on the top of the silo was evaluated with a commercial structural mechanics code, ABAQUS, considering crushed rocks and shotcrete above the waste.

2. Methods

2.1 Disposal container and solidified waste

The concrete disposal container containing 16 solidified waste drums of 200 l was introduced in the ABAQUS simulation to estimate the deflection of waste container and mechanical stress of the solidified waste as shown in Fig. 1. The cover of the container is supported by four triangular poles at the corner and placed slightly higher than the height of the waste drums. The wastes loaded in the container were assumed as solidified with concrete, and the steel drums were not considered for simplifying the computational modeling. The material properties of the container and the solidified waste were described in Table 1.

Element type C3D20R that is a 20-node quadratic brick with reduced integration was applied to enhance the convergence of calculation and reduce the calculation cost.

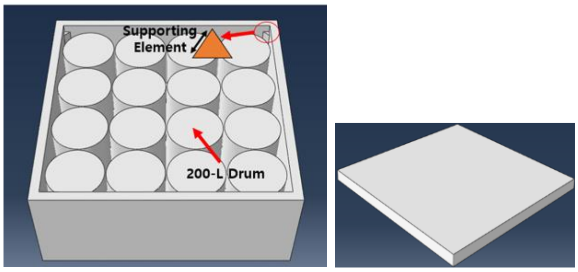

Fig 1. Geometry of the disposal container with 16 waste drums (left) and cover(right)

Table 1. Material properties of the disposal container and the concrete solidified wastes

Density	2300 kg/m^3
Elastic Modulus	25 GPa
Poisson ratio	0.2
Applied Pressure	0.34 MPa

2.2 Loads on the disposal container

In the silo of the Gyeongju repository, 30 disposal containers are going to be stacked up and the granite crushed rocks and shotcrete will be piled about 15 m over the stacked containers as represented in Fig. 2. In this study, the container placed on the top of the silo was simulated, so the expected loads on the container result from the weight of the crushed rocks and shotcrete. The pressure of 0.34 MPa was utilized as the loads on the top container with the assumption of the composition of crushed granite of 70 wt% and shotcrete of 30 wt% [3]. The bottom of the container was fixed as the constraint, and the other parts were not.

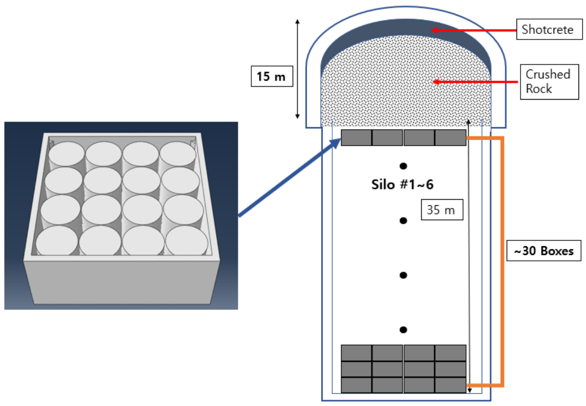

Fig 2. Structure of the silo and 16-pack container in Gyeongju LILW repository

3. Results

Fig. 3 shows the displacement of the disposal container cover and the mechanical stress of the solidified waste. In the figure, negative sign means downward displacement and stress. The cover is deformed enough in a vertical direction to result in a contact with the solidified waste by only the loads from the crushed rocks and shotcrete, and the loads can be transferred to the waste. All wastes are under the pressure about 2.299 MPa, marked as a green color in the figure, and maximum stress of 3.55 MPa can be applied to the several wastes. Therefore, all soft solidified wastes with 0.41 MPa compressive strength criterion would be collapsed by 2.299 MPa and some hard solidified wastes with 3.44 MPa compressive strength criterion would be collapsed by the maximum stress which is 3.55 MPa.

Due to the short lifetime (less than 100 years) of the concrete container, the 16-pack disposal container will lose its structural function and it might be under larger pressure. Also, in the aspect of the waste in the bottom, it would be under more pressure than the top container due to the weight of the upper containers.

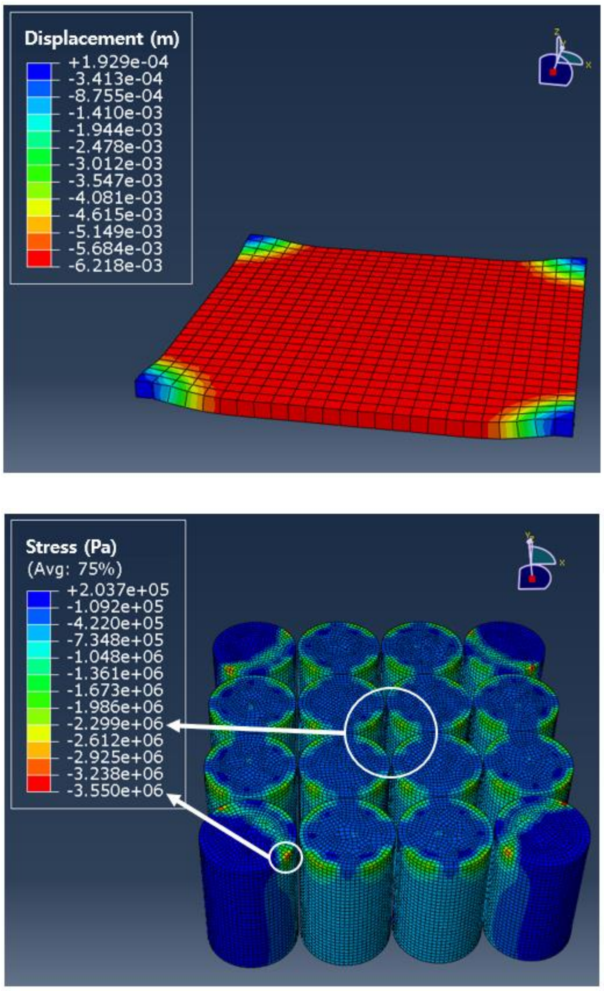

Fig 3. Deflection of the disposal container cover (up) and mechanical stress of the solidified waste (down)

4. Conclusions

The silo type LILW repository in Gyeongju adopts compressive strength criteria same as those of an NRC report on waste acceptance criteria for a trench type. To evaluate the suitability of the current criteria, the mechanical strength for the disposal container and the solidified waste located at the top of the silo was calculated with ABAQUS by considering the crushed rocks over the container. The maximum predicted compressive strength was 3.55 MPa much higher than the current criterion for a soft solidified waste (0.41 MPa), and slightly higher than the criterion for a hard solidified waste, 3.44 MPa. When considering the loads on the bottom disposal container, the mechanical stress of the waste in the Gyeongju repository could be much higher than the current compressive criteria. Therefore, it would be necessary to introduce new mechanical strength criteria for the solidified waste considering the anticipated load from stacking waste containers and crushed rocks in the Gyeongju repository.

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