A Preliminary Study of Hydraulic Performance Assessment of a Multi Barrier System in Near Surface Disposal Facility

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1. Introduction

The radioactive waste repository has been operated to store low and intermediate-level radioactive waste at the Wolsong site in South Korea. The second stage repository is planned to be built in shallow depth conditions at the same Wolsong site. The multiple engineered barrier cover system will be constructed to protect the near-surface disposal facility. After a long term period of time, the barrier cover system may lose integrity and precipitation may infiltrate into the concrete vaults. Therefore, the barrier cover system should be maintained for a long period of time and should be minimized when the performance is lost.

In this paper, rainfall infiltration through the multiple barrier cover will be approached and assessed using 2-dimensional groundwater flow modeling.

2. Materials and Methods

2.1 Design of multiple engineered barrier cover system

The primary objective of the barrier cover is to limit the amount of water that passes through the cover and the amount of water potentially contacting wastes. The cover of the second stage disposal facility is composed of different layers : surface layer, drainage layer, and barrier layer. The configuration of the cover is shown in Fig. 1 [1].

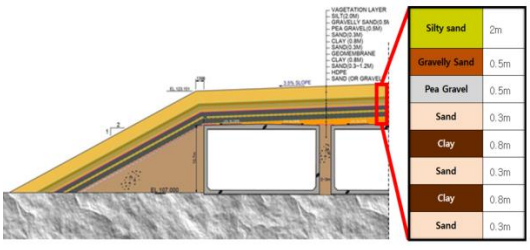


Fig. 1. Configuration of multiple engineered layer cover in Wolsong LILW 2nd stage disposal facility.

2.2 Concept model

The second stage near-surface disposal facility at ground level is 171 m wide and 67 m high, which corresponds to 10,209 m^2. The groundwater table located approximately 50m from the bottom of the concrete vaults [1].

It is assumed that the cover maintains its function for 300 years, and then the properties of all layers change to sand or clay.

2.3 Rainfall conditions

To set the rainfall conditions, the recharge amount of the disposal cover was estimated by applying the daily precipitation based on of Ulsan's annual precipitation for 30 years. In the case of 300 years, 10 sets of 30-year rainfall were applied.

2.4 Hydraulic properties of cover

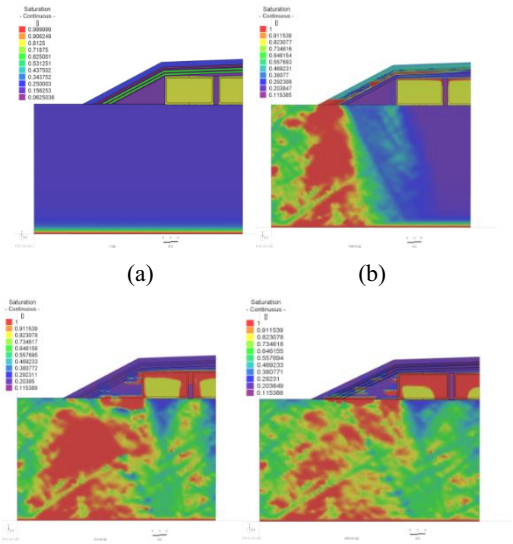
The hydraulic properties of silty sand, gravelly sand, pea gravel, sand, clay, and concrete vault are listed in Table 1[2]. The hydraulic conductivities of the unsaturated zone were applied to the results of discrete fracture network modeling.

Table 1. Properties of multi-barrier cover materials

Layer	Water Content		Van Genuchten Parameters		Saturated Hydraulic Conductivity (cm/s)
	Residual	Saturated	α (cm^{-1})	n	
Silty sand	0.1	0.47	0.044	1.523	1.00e-04
Gravelly sand	0.02	0.32	0.1008	2.922	1.00e-02
Pea gravel	0.03	0.26	4.695	2.572	1.00e+00
Sand	0.045	0.37	0.0683	2.08	3.00e-02
Clay	0.0001	0.36	0.0016	1.203	1.00e-07
Concrete Vault	0.08	0.40	0.0063	1.08	1.00e-8

3. Results

The change of saturation distribution over 1,000 years is shown by Fig. 2 and 3. As the saturation continued for 300 years, Infiltrated water collected in the sand layer at the lower-most part of the drainage layer, and most of the infiltrated water flowed down the slope.

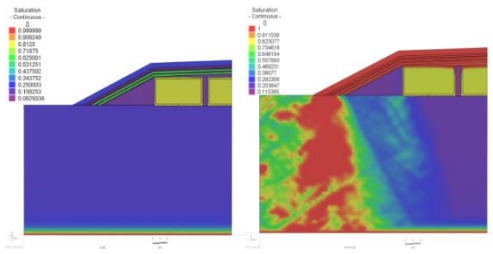


(a) (b)

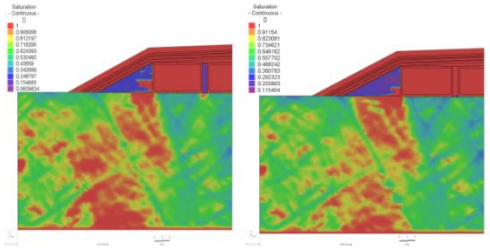
(c) (d)

Fig. 2. Saturation distribution of changing to sand properties after (a) 0, (b) 300, (c) 600, (d) 1000 years, respectively.

When the performance of the multiple barrier cover was compromised, the rainfall came in contact with the concrete storage well. As a result of checking path lines distributions, it was found that the infiltration water to the inside of storage is extremely small compared with the precipitation amount, which was confirmed by calculation of the infiltration volume.



(a) (b)



(c) (d)

Fig. 3. Saturation distribution of changing to clay properties after (a) 0, (b) 300, (c) 600, (d) 1000 years, respectively.

4. Conclusion

After a long time period, even if all the layers had the properties of sand or clay, the infiltration rate was low. In order to improve the reliability and validity of the simulation results, various future studies such as estimation of recharge amount and degradation of concrete, are required.

REFERENCES

[1] Mi-Jin Kwon and Ki-Jung Kwon, “Barrier of near-surface LILW disposal facility in Korea : hydraulic model development”, 6th EA Forum on Radwaste Management Conference (2017).

[2] Nuclear Regulatory Commission, “Application of an infiltration evaluation methodology to a hypothetical low-level waste disposal facility”, NUREG/CR-6114 PNL-8842 Vol.1 (1993).