Probabilistic Safety Assessment for LILW Silo Repository in Earthquake Scenario Using Domestic Earthquake List

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1. Introduction

To understand and examine the safety of disposal facility, we developed the safety assessment model with the Monte Carlo based simulation frame, Goldsim, and analyzed both the radio-biological effects and the sensitivity of various input parameters [1]. From our previous studies, it was observed that the safety of repositories in a normal scenario is highly achievable. The robustness in safety, meanwhile, should be guaranteed for various abnormal scenarios as well.

In this work, the safety assessment model is newly modified to evaluate the safety of disposal facility under the earthquake scenario, and the domestic earthquake list was adopted for site-specific assessment. Simultaneously, we developed an earthquake analysis program with the template of MATLAB to reinforce the utilization of the research results.

2. Model Description

2.1 Development of the domestic earthquake list analysis program

The earthquake occurrence characteristics highly depend on the geological domain of interest. Therefore, hypothesized earthquake data could increase the uncertainty of safety assessment results. To enhance the reliability of results, we applied the domestic earthquake list to safety assessment model.

In general, the cumulative number of earthquake events according to their magnitude is described following the Gutenberg-Richter (G-R) relation,

$$\log_{10} N(M) = a - bM \quad (M > M_c) \qquad (1)$$

where N(M) is the number of earthquake events, which have the magnitude greater than M. The M_c is the threshold of the magnitude, which indicates the smallest magnitude that the G-R relation is applied to the particular earthquake list.

The annual occurrence rate of an earthquake was estimated by MATLAB-based earthquake list analysis program with the G-R relation. In addition, the distribution of the distance between repository and epicenter and the probabilistic distribution function for the magnitude of earthquakes were obtained by using analysis program.

2.2 Performance assessment module for an earthquake scenario

The figure below shows a schematic diagram of the newly developed earthquake scenario module. Most of other modules (i.e. silo repository module and biosphere module) are basically identical to the model used in the previous study [1].

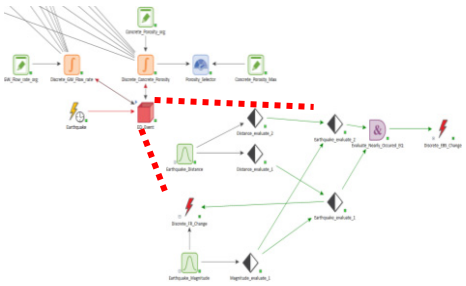

Fig. 1. Schematic diagram of earthquake scenario module.

The yellow thunder shape element in Fig. 1 is the ‘timed event element’. In the Goldsim program environment, this element was employed to estimate the time intervals between events (earthquakes), and the Poisson distribution, which is usually used to predict the occurrence of an earthquake [2, 3], was implemented in this element.

Similar to previous studies [4, 5], not only the magnitude of an earthquake but also the distance from epicenter to the repository were utilized to select the ‘valid’ earthquake among all events. The assumption for this process are listed in Table 1.

Table 1. Assumption of earthquake scenario

Criterion	Threshold	Effect
Distance from epicenter to repository	≤ 8 km	Increase the groundwater flow rate
	≤ 3 km	Increase the porosity of EBS (concrete barrier)
Magnitude	≥ 4	Increase the groundwater flow rate

3. Modeling Result

For the probabilistic safety assessment, 1,000 earthquake scenarios are simulated as shown in Fig. 2, which shows the annual dose rate of all cases. Within a few centuries, no significant difference among the scenarios was observed. The maximum annual dose rate within the 1,000 simulations was reached to 2.34×10^{-5} mSv/yr, which is negligible compared to the safety limit for the normal scenario, i.e. 0.1 mSv/yr.

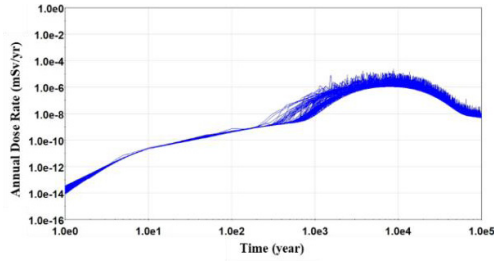

Fig. 2. Annual dose rate obtained from 1,000 simulations.

In addition, the risk for the earthquake scenario was calculated based on the 1,000 simulations, and the risk assessment results are depicted in Fig. 3. The maximum risk of 5.81×10^{-11} yr^{-1} as well as the annual dose rate were much smaller than the safety limit.

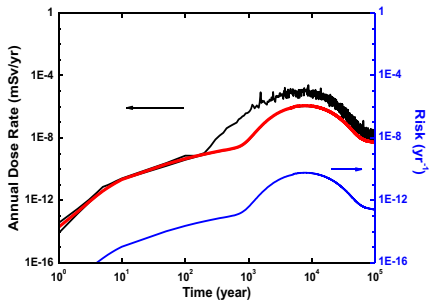

Fig. 3. Risk assessment results of earthquake scenario.

4. Conclusions

From the multiple earthquake scenario simulations, it was deduced that the repository provides a robust safety against for the seismic effect, and no simulation case exceeds the safety limit. In particular, the maximum risk of 5.81×10^{-11} yr^{-1} calculated from this work corresponds to 0.006% of the regulatory criterion of 10^{-11} yr^{-1}.

5. Acknowledgement

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