Conceptual Modeling for Local Two-Dimensional Radionuclide Transport with Discrete Fracture Network in Wolsong LILW Disposal Center

Joo-Wan Park, Sung-Wook Hong, and Doo-Hyun Lim*
Korea Radioactive-waste Management Corporation, 848-2, Jung-dong, Giheung-gu, Yongin, Korea
*Golder Associates Inc, 18300 NE Union Hill Road, Suite 200, Redmond, WA 98052 USA
p5j9w@krmc.or.kr

1. Purpose and Background

According to the follow-up action program, which was officially requested by regulatory authority, as a licensing condition of Wolsong LILW Disposal Center(WLDC), safety re-assessment is needed to gain the safety margin of disposal facility by reflecting tunnel excavation data, concrete silo design and surrounding rock characteristics. In this respect, a new conceptual modeling which is different from the previous license application stage's radionuclide transport assessment is attempted. In the previous assessment, groundwater flow modeling with hybrid approach was used where hydraulic conductivities of the rock domain were determined from the discrete fracture network(DFN) method. Then the results of groundwater flow modeling were used as inputs to one-dimensional compartmental radionuclide transport model. New approach is to reflect the interference of radionuclide transport in multiple-silo configuration and the heterogeneity of the fractured rock in silo-scale two-dimensional domain[1,2].

2. Conceptual Modeling

The current model consists of six underground silos, engineered barrier systems(EBS), excavated damaged zone(EDZ), and host rock zone. Three EBS zones for each silo consist of waste zone comprising waste packages and disposal container, buffer zone, and concrete lining zone. Figure 1 illustrates model conceptualization. EDZ is the disturbed zone adjacent to silos and tunnels due to construction and emplacement EDZ has the potential to induce changes in flow and transport properties and therefore has the potential for a significant effect on the long-term performance of radioactive repository. Primarily cause of EDZ effects is the stress redistribution due to the excavated tunnel i.e., man-made openings in geologic formations[3].

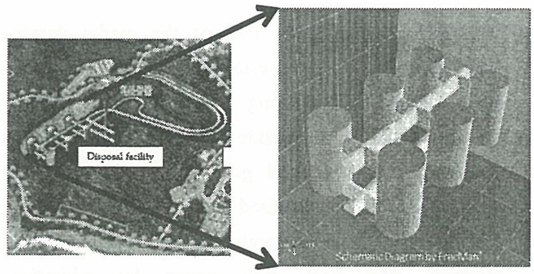

Fig. 1. Model conceptualization: Silos and Tunnels

Excavation processes induce EDZ effects, depending on the excavation method such as TBM, NATM, Drill, Blast, etc. The domain for groundwater flow and radionuclide transport can be subdivided into four different regions, i.e., waste, buffer, concrete, and host rock regions. Waste, buffer, and concrete zones are considered as homogeneous isotropic water-conducting medium with different hydraulic/material properties. Host rock is divided in two regions, rock matrix and DFN region. Rock matrix region does not contain any water-conducting fractures, while DFN region is considered to be an equivalent heterogeneous anisotropic continuum characterized by waster-conducting fractures. The concept of two-dimensional flow and transport model is shown in Figure 2.

DFN fracture data analysis utilizing borehole data near silo region and multiple stochastic Monte Carlo realizations of DFN is to be performed. Groundwater flow is simulated for the steady-state, incompressible Darcy flow with space-dependent hydraulic conductivity in two-dimensional Cartesian coordinates.

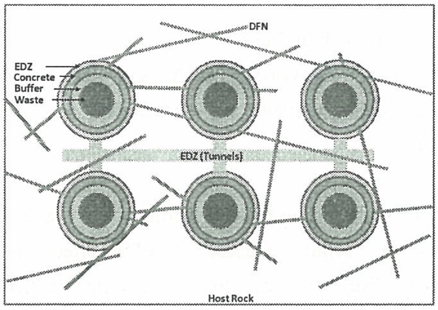

Fig. 2. Concept of two-dimensional flow and transport model

A heterogeneous flow field of the model domain with multiple silos is established over the entire model space by obtaining a space-dependent flow velocity field. Radionuclide migration is simulated based on the established groundwater flow velocity field. Radionuclides released from each of the waste zone inside of silo migrate through waste, buffer, concrete, and host rock zones by advection/ dispersion(diffusion), sorption, and/or decay. Radionuclide transport can be simulated using the random-walk particle tracking method. Particle tracking will be used in the current model because it can be easily combined with any flow model and does not show the numerical dispersion.

3. Conclusion

An integrated model for groundwater flow and radionuclide migration analyses in the WLDC with a multiple-silo configuration is to be developed in the two-dimensional space by incorporating the heterogeneity of fractured host rock. For this purpose, more reliable conceptual modeling which is different from the previous approach in license application stage is attempted. This model is expected to gain the safety margin of the WLDC.

4. References

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[2] Doo-Hyun Lim, "Numerical Study of Nuclide Migration in a Nonuniform Horizontal Flow Field of a High-level Radioactive Waste Repository with Multiple Canisters", Nuclear Technology, 156, 222-245, 2006.

[3] Tsang et al, "Geohydromechanical Processes in the Excavation Damaged Zone in Crystalline Rock, Rock Salt, and Indurated and Plastic Clays in the Context of Radioactive Waste Disposal", International Journal of Rock Mechanics and Mining Sciences, 42(1), p109-125, 2005.