Preliminary results of groundwater flow simulation for high level radioactive disposal in Yu-seong area

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Abstract

This research aims to demonstrate the regional and site scale groundwater flow simulation for the high level radioactive disposal research site in Yu-seong. We used the Modflow by a finite difference method for groundwater flow simulation, and Modpath module in Modflow package for particle tracking simulation. The range of numerical domain for regional groundwater flow model is 16.32km×20.16km. And, the depth of numerical domain was expanded to 6,000m. The area of numerical domain for the site scale groundwater flow simulation is 1.6km×1.6km.

Since 2005, the underground research tunnel(URT) is being constructed at KAERI(Korea Atomic Energy Research Institute) site. In the site scale groundwater flow model, the groundwater flow around the KAERI site is simulated. And the change of groundwater level with tunnel excavation is also predicted.

1. Introduction

The hydrogeological safety assessment of high level radioactive waste disposal site is focused not only the surface and shallow geo-environment but also deep geologic environment. Generally, a deep geological element is mainly composed of a crystalline rock. Because the fractures are only considered as conductive features, it is very important to identify the conductive fracture system of a deep environment. Unfortunately, the analysis of fracture system in the deep environment is very difficult by the lack of geologic information. So, it is a general approach method that the regional groundwater flow in the fractured rock mass can be considered as the phenomena occurring at continuum porous medium. From this point of view, the REV(representative element volume) had to be smaller than the volume of numerical domain. And, deterministic fracture system also must be included in the numerical domain(Bear,1993).

But, during the site scale flow simulation, a local fracture system as conductive features must be identified through the geologic and hydrogeologic investigation.

This paper will explain about the preliminary results of groundwater flow simulation at regional scale and site scale with the concept of continuum porous medium. After this, regional and local fractures will be considered deterministically and statistically at the numerical simulation.

2. Numerical simulation

1) Regional scale groundwater flow

The objectives of the regional scale groundwater flow simulation are following. The first objective is to understand the regional groundwater flow in study area. The second objective is to determine the hydraulic bottom boundary affected by geographical condition. And, the third objective is to analyze the possible pathways from the imaginary repository site by using the particle tracking method. For accomplishing the above objectives, we used numerical software "Modflow package (Harbaugh, 1996)" by FDM.

We carried out the numerical simulation of the regional scale groundwater flow including the KAERI site. The range of the numerical domain is 16.32 km × 20.16 km. To understand the regional groundwater flow system, the domain depth was expanded to EL -6000m. During the numerical simulation for regional scale groundwater flow, several assumptions were considered. At first, the numerical domain was a continuum porous medium. And, the hydraulic soil domain was not considered. The pumping activities for agricultural use and hot spring which affect the hydraulic system of domain were also ignored. And the domain is composed of a stable rock mass.

2) Site scale groundwater flow

The background of the site scale groundwater flow simulation can be summarized as assessing the groundwater drawdown during the excavation. Also we need to know the baseline conditions before and after the excavation. We will conduct the various in-situ hydro-tests and experiments in KURF. Therefore, it is necessary to know the groundwater flow system evolved from the excavation. From the modeling, we aim to evaluate the hydraulic boundary conditions and to re-evaluate hydraulic parameters through a model calibration, especially hydraulic conductivities Other objective is to predict the groundwater flow system after the first excavation level.

We used MODFLOW for modeling code and designed the model using the data investigated in the KAERI site. And then, the model was calibrated by using the inflow measured in the tunnel and the groundwater table measured from three boreholes in the vicinity of the URT during the excavation up to 104m. Finally, with the calibrated model, the groundwater inflow rate and groundwater table were predicted after excavation to 235m.

A modeling area is about 1.6km×1.6km. A hydraulic boundary was set at the location where hydraulic condition is not influenced from the tunnel excavation, for example, valley, fracture zones anticipated from lineament and small streams. For the boundary conditions, around the top of the uplands is applied by general head boundary. The contact area of the small streams to agricultural low land is assigned to constant head boundary. The river boundary used for the valleys and small streams Initial groundwater tables in the top layer were based on the data from the boreholes in the KAERI site. The tunnel was assigned by constant head boundary under the atmospheric pressure. Due to a slope of ten percents, the potential head of the tunnel is estimated to EL. 88.25 m at the middle of the tunnel. The initial values of the input parameters assigned in the model are as follows. The hydraulic conductivities were used as the data evaluated from YS-1 to YS-7 boreholes. And recharge rate, storage coefficient, and porosity were applied by the general values.

3. Results

Through the numerical simulation of regional groundwater flow, we concluded that the groundwater flow of upper layer is mainly governed by the geographical condition. According the results of velocity fields in numerical domain, there are several local and regional flow regimes. The local groundwater flow is absolutely governed by the geographical condition and the regional groundwater flow pattern run in the direction of NE or NNE. The depth affected by geomorphology is about 2.4km. So, the hydraulic bottom boundary must be expanded to over 2.4km. The particle pathways from the imaginary disposal area run into the NE, E, SE direction.

From the results of the site scale groundwater flow simulation, we concluded that the area having draw-down over 1m extends from the center of the tunnel to maximum 343m. This result indicates that the draw-down is not affected by the hydraulic boundary set up initially. To analyze the draw-down in detail, the hypothetical observation wells are installed in the model. One is approximately 5m from the tunnel wall and the other is 200m from the tunnel wall. And, the wells adjacent to the tunnel show the draw-down ranged from 5 to 20m. After the excavation, it is predicted that the groundwater table will somewhat rapidly fall within 274 year. This draw-down phenomenon maybe resulted mainly from the steep topography and low recharge rate used in the model.

Reference

Bear, J., et al., "Flow and contaminant transport in fractured rock", Academic press, United Kingdom, 6-10 (1993)

Harbaugh, A., et al., "User's documentation for MODFLOW-96, an update to the US Gelogical Survey modular finite-difference ground-water flow model", Open-File Report 96-485, US Geological Survey (1996)