Development of multi-scale modeling for estimation of inflow volume into tunnels of the geological disposal facility

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During the construction and operation of underground tunnels for geological disposal, groundwater inflow into the tunnels may occur. It is necessary to drain the inflow of groundwater to the ground surface. In case if inflow volume is large, the hydrochemical environment around the tunnel may be disturbed by up-corning the deeper water such as brine and/or drawing in the near surface water into the disposal depth. Therefore, it is important to estimate the inflow volume and to prepare measures to effectively reduce the inflow volume, prior to the construction of the underground tunnels. We therefore developed a method for estimation of inflow volume into the tunnels and effect of its decrease by applied countermeasures.

We developed the hydrogeological model for plutonic rocks, Neogene sedimentary rocks, and pre-Neogene sedimentary rocks, which are widely distributed in Japan and the modeled areas have suitable features for geological disposal. In this report, an application of our evaluation method of estimating inflow volume to the plutonic rocks model is reported.

In the case of Plutonic rocks, faults and fractures are to be characterized during site investigations since these may be the major pathway of groundwater flow. In order to develop a hydrogeological model, distribution of faults and fractures, and their transmissivity were stochastically generated using the discrete fracture network method. The hydrogeological model is composed of two different domains with different discretized mesh size; a repository scale (set to 5 km x 5 km x 1.5 km) including the underground tunnels, which is for modeling detail hydraulic heterogeneity, and a regional scale (set to 50 km x 50 km x 5 km) for setting hydraulic boundary conditions for the repository scale model.

Underground tunnels will be placed in an area where safety can be ensured during the construction, operation and after closure, taking into consideration of properties of the host rocks and distribution of the faults and fractures at the targeted depth. During construction and operation, disposal zones are divided into the ones for construction and the one for operation, and the works are carried out in parallel. It is thus important that the safety of workers is ensured in both zones. For example, there is a possibility of having abnormally large inflow when high conductive fault and tunnel are intersected each other. In order to lower the risk, the disposal zone in which many disposal tunnels are lined up in parallel should not be located where a water-conductive fault exists and the zones for construction and operation are not directly connected to avoid potential interactions, e.g. large amount of water flows in each other.

In this study, inflow volumes considering several types of tunnel layouts were estimated. As results, inflow volume into the access tunnels, which connects from surface to underground, was the largest and inflow volume into the disposal tunnels were relatively small. The reason of this result is analyzed that the disposal tunnels are located in parallel, thus local drawdown of the water table occurred around these tunnels, which result in the inflow volume is smaller than that evaluated for a single disposal tunnel. On the other hand, the access tunnel was open throughout the period of construction and operation, so the inflow volume was relatively large. The measures for reducing inflow volume such as grout at the access tunnel are effective.

The key-finding of this study was that the developed multi-scale modeling method is effective in estimating the groundwater inflow volume taking into account variation of tunnel layouts and application of measures of water inflow control. As further R&D, we are also trying to apply this method to estimate how the hydro-chemical environment changes with groundwater inflow during construction and operation of the repository.

