Priority Subjects — **Establishment of Optimal Risk Management**

Development and Systematization of Long-term Safety Assessment Technologies for Radioactive Waste Disposal

Background and Objective

As storage capacity of the low-level radioactive waste (LLW) in nuclear plants is growing tight, the licensing safety of pit and sub-surface disposal require review based on a planned schedule. Moreover, in regards to high-level radioactive waste (HLW), the Japanese government is engaged in various efforts such as investigating direct disposal, securing safety in the future, the systemization of site selection and so on.

In this project, R&D of LLW disposal aims to develop methods to evaluate hydraulic conductivity and to evaluate migration characteristics of engineered barriers in order to build a reliable technology. R&D of HLW disposal aims to develop methods to evaluate the residence time of groundwater and to select cementitious materials for the different components in a disposal facility.

Main results

1 Hydraulic conductivity test for Ca-type bentonite-sand mixture

Ca-type bentonite-sand mixture will be used in low-level radioactive waste disposal facilities. A hydraulic conductivity test of soils has been standardized in JIS, but the JIS method is not applicable to low permeable soils such as bentonite. This study improved the JIS method for Ca-type bentonite-sand mixture. It became possible to evaluate the saturation of specimens before permeation, and to discuss the effect of plugging by fine particles (Fig. 1). It is expected that this report will contribute to new standardization (N13005).

2 Evaluating gas migration characteristics of compacted Ca-bentonite mixture

Since the gas permeability of Ca-bentonite mixture is low, it is necessary to investigate the effect of gas pressure generated mainly by the chemical interaction between aluminum and the alkaline component of cement. Thus, gas migration tests together with their numerical simulation were conducted using CRIEPI's code. As a result, it was revealed that the in-situ gas breakthrough pressure is thought to be smaller than the gas breakthrough pressure measured by the gas migration test due to the difference in stress caused by different boundary conditions.(Fig. 2)(N13011).

3 Estimating residence time of groundwater contaminated by drilling fluid

Understanding the migration of groundwater is required for safety assessment of HLW and the residence time of groundwater (RTG) is useful information for this. RTG can be assumed by radiocarbon (^{14}C) in the dissolved natural organic matters (NOM). However it is frequently contaminated by artificial organic matters (AOM) added in drilling fluid. The separation method between NOM and AOM has been established. This method has enabled the correct estimation of RTG by using ^{14}C in NOM. (Fig. 3) [1]

4 Investigation of the methodology used in selecting cementitious materials for the different components in the underground facility

The objective of this study is to list and sort the required characteristics of cementitious materials for each component in the facility, in order to provide input for determining material selection methodology. When deriving the required characteristics of cementitious materials for each component, physico-chemical properties were investigated that will fulfill required operational functions and minimize effects on the safety function of the disposal system due to alteration or degradation. Based on these investigations, step changes in the state of the disposal system are identified, including the bedrock around the drifts, by considering alteration or degradation of the cementitious material. Significant components for ensuring safety function can be identified by specifying the step changes in the state of the disposal system. (Fig. 4)(N13009)

[1] Nakata, K., Kodama, H., Hasegawa, T., Hama, K., Iwatsuki, T., Miyajima, T., Journal of Hydrology, 489, pp.189-200, 2013.

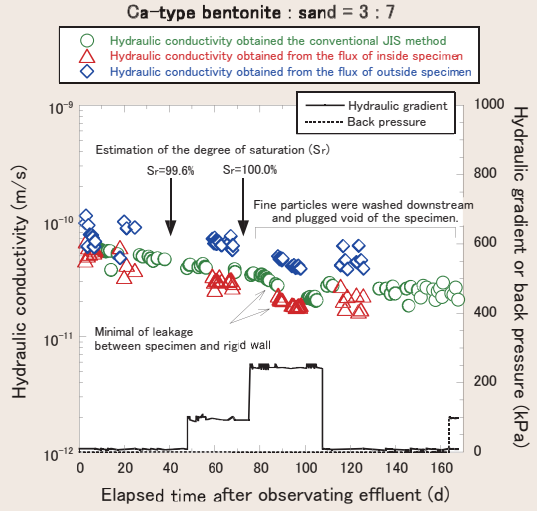


Fig. 1: Experimental result of a hydraulic conductivity test

The slight decrease in hydraulic conductivity after saturation was determined to be caused by the clogging of fine particles. Measuring the flux of inside specimen showed that the conventional JIS method was substantially applicable to Ca-type bentonite-sand mixture.

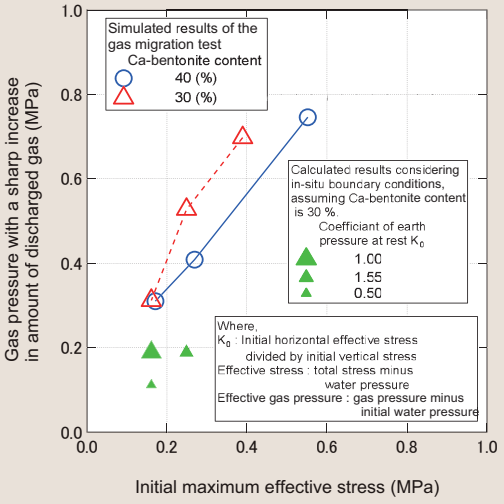
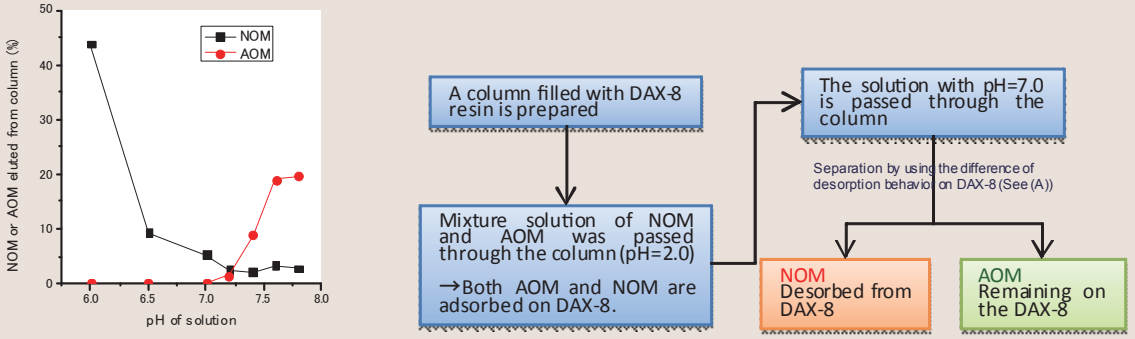


Fig. 2: Gas pressure with a sharp increase in amount of discharged gas

In-situ gas pressure with a sharp increase in amount of discharged gas is smaller than that evaluated by laboratory tests because of difference in initial stresses and reaction forces from surroundings.



(A) pH vs amount of eluted organic matter

(B) Flow chart of separation between NOM and AOM

Fig. 3: Separation between NOM and AOM and measurement of ^{14}C in NOM

Separation of natural organic matter (NOM) and artificial organic matter (AOM) has been achieved by using their respective differences in sorption and desorption behavior on DAX-8 resin.

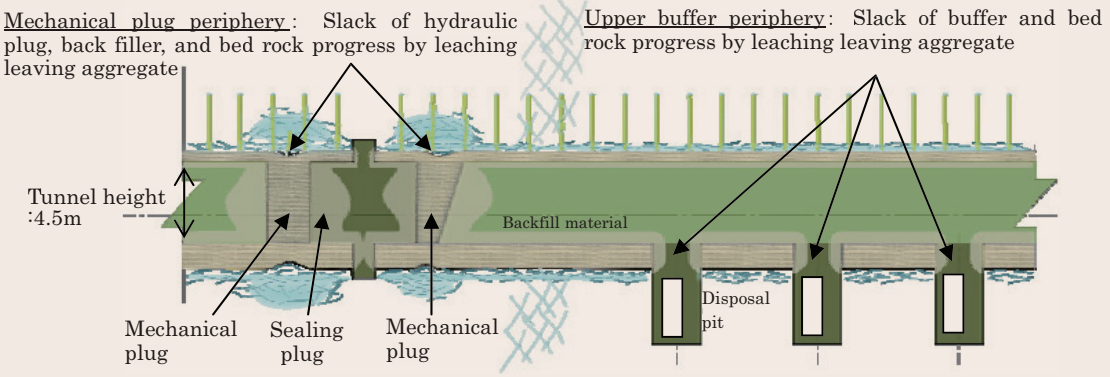


Fig. 4: Trial estimation on mechanical and chemical state transition of HLW underground facility

Due to the progression of leaching of ions from cement hydrated phase in concrete, surrounding area of the mechanical plug and buffer will loosen. Considering such a long-term state transition, the material and mechanical design of concrete components should be made a priority issue.