Application and Confirmation of the Computational Codes for Groundwater Flow and Radionuclide Migration in International Cooperative Research Work with SKB (Sweden)

Background

High-level radioactive waste will be finally disposed of in a deep underground rock formation and a confirmation study in the underground research laboratory is indispensable to establish the performance assessment method for the disposal facility. Cooperative research work with western advanced countries becomes important because there is no actual underground research laboratory in Japan.

CRIEPI has participated in international cooperative research work in the underground research laboratory (HRL) with the Swedish Nuclear Fuel and Waste Management Co. (SKB) since 1991. From the viewpoint of waste-producing electric utilities, CRIEPI seeks to confirm the applicability of the performance assessment method, especially for a natural barrier system, to dispose of waste in a rational and smooth manner.

In this research, an investigation or evaluation technique for the groundwater flow and the radionuclide migration in the rock formation developed by CRIEPI was applied and it was investigated whether this technique could be applied practically with the satisfactory precision.

Purpose

To evaluate the groundwater flow in the pathway through which radionuclides move from the high-level radioactive waste disposed of in the deep underground rock formation, applicability of the computational code (natural barrier performance assessment method) which CRIEPI has developed to the field data is confirmed by comparing with the field data.

Principal Results

1. Application of the modeling technique of the hydro-geology structure

Although various types of systematically acquired data become necessary to confirm the applicability of the modeling technique of the hydro-geology structure, it is difficult to obtain these data under present conditions in the actual field in Japan.

The smeared fracture model developed by CRIEPI was applied to the Aspo HRL site in which fracture/fault zones existed abundantly and the modeling of the hydro-geology structure necessary for finite element analysis was carried out. (Figure 1) Although one excavated underground tunnel and nineteen major fracture/fault zones must be expressed within this analytic territory, this model has the advantage that an complicated element form can be avoided against the precision target and a change such as position or width of the fracture zone in the analytical modeling is completed much more easily because the finite element division can be done regularly without modeling the distribution of fracture zones.

In this analytic method, the idea of modeling a tunnel part could be considered as a line/plane element in the modeling, too. Compared with the actual condition before, it was confirmed that finite element models could be applied by simple practical handling with full consideration given to hydro-geologic structure. (Figure 2)

2. The application of CRIEPI's groundwater flow analysis code to the in-situ test for groundwater change along with the tunnel digging

The groundwater flow analysis code (FEGM) developed by CRIEPI was applied based on the above-mentioned geology model to the draw down of groundwater table along with the digging of a tunnel extension about 3700m at 460m depth and an analysis was done. As this result, by taking into account the effect of grouting against the spring out of groundwater in the tunnel, a good agreement between the observed result for the water level change is shown, and it was confirmed this analysis code could be applied with satisfactory precision. (Figure 3)

3. Application of CRIEPI's analysis code for the radionuclide migration to the tracer test along with up-lifting of groundwater in fracture zones

The analysis code (FERM) developed by CRIEPI was applied to the tracer test in which Uranine is used as a tracer along with up-lifting of groundwater in a bored center well-arranged around the radiation-shaped tracer injection wells. As for permeability distribution in this analysis, the permeability coefficient distribution inside the fracture zone was estimated in a statistical analysis.

By carrying out the analysis in consideration of the groundwater flow of the circumference, for the most part, good agreement between the observed value and the analyzed result was obtained and the applicable effectiveness of this analysis code was confirmed. (Figure 4)

Future Initiatives

The analysis codes for the groundwater flow and radionuclide migration to the in-situ tests will continue to be applied. Their applicability will be then confirmed and the analysis code for the radionuclide migration will be newly applied in consideration of the chemical reaction, etc. Furthermore, the groundwater survey techniques developed by CRIEPI for groundwater aging and groundwater flow velocity/direction will be applied to grasp the actual condition of groundwater flow at Aspo.

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Reference

• T. Igarashi, Y. Tanaka, M. Kawanishi: Application of three-dimensional smeared fracture model to the groundwater flow and solute migration of LPT-2 experiment, SKB Report ICR 94-08, Oct. 1994.
• Y. Tanaka, Kimio Miyakawa, T. Igarashi and Y. Shigeno: Application of three-dimensional smeared fracture model to the hydraulic impact of the Aspo tunnel, SKB Report ICR 96-07, Oct. 1996.

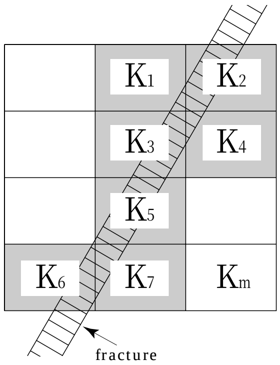
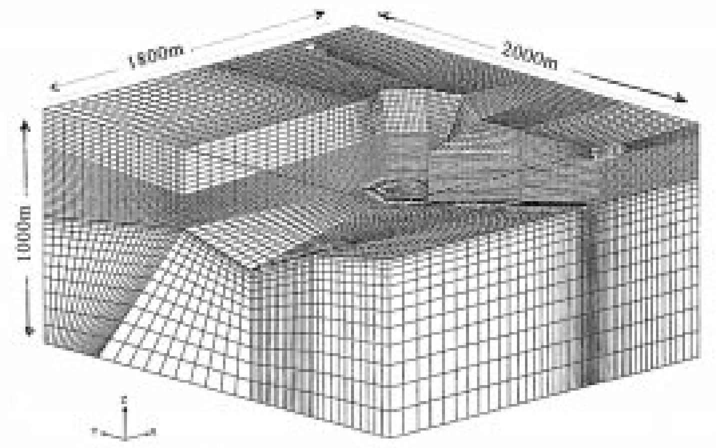


Fig. 1 Smeared fracture model ;The value of material for each element (K_1~K_7) that a fracture passes is changed by the volume proportional allotment



Rock matrix (Smeared elements are contained) ;168,141 porous media elements, 98 tunnel line elements, 45 shaft (three) line elements

(a) Finite element models

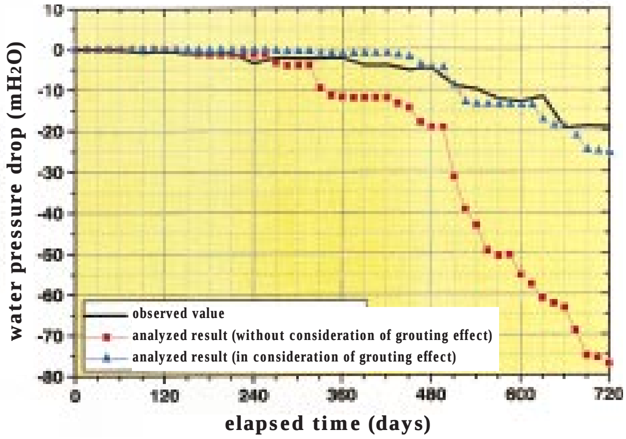
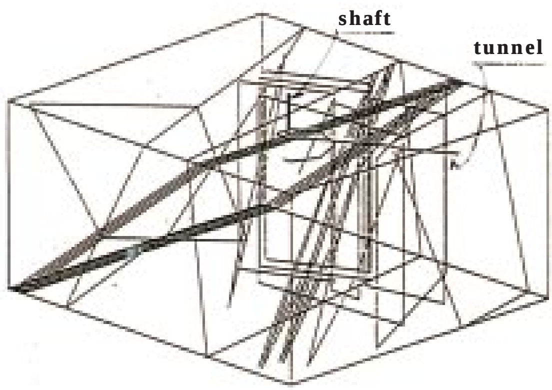
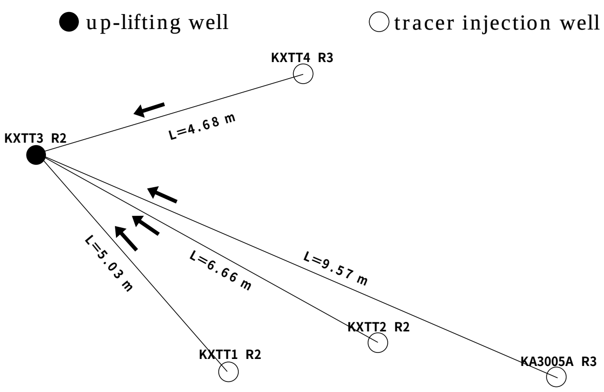


Fig. 3 Comparison between the observed value and analyzed result by FEGM code; for the evaluation of the groundwater level change in a bored well in consideration of grouting effect

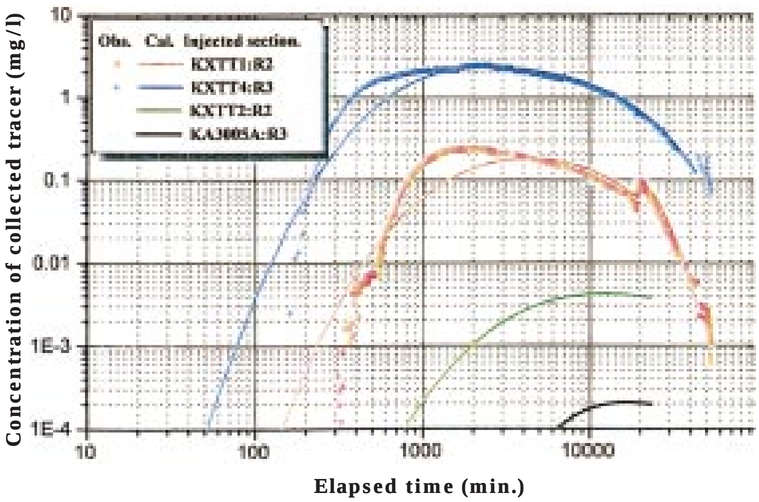


(b) Distribution of main fracture zone and tunnel/shaft

Fig. 2 Construction of the hydro-geology model in consideration of the fracture zone and the tunnel; establishment of the hydro- geology structure model for the finite element method



(a) Tracer injection wells that it are arranged in a radiation-shape around tracer injection center well



(b) A comparison of the observed value with the calculated result;

tracer is poured into KXTT1 and KXTT4 wells, after several hours to two weeks, the concentration of tracer in the up-lifted water

Fig. 4 Application of the radionuclide migration analysis code FERM developed by CRIEPI for the tracer test in a fracture zone along with the up-lifting of groundwater