Performance Evaluation of Constructing Topography and Fracture Network in Multi-Dimensional Probability Safety Assessment code

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1. Introduction

With the advances in numerical scheme and machine, various commercial codes are developed and utilized in predicting radionuclide transport calculations such as MASCOT[1] and CONNECTFLOW[2]. However some limitations have encountered in simulating hydro-geological characteristics of granite rock, which is considered as an expecting repository site rock in Korea[3] : Unavailability in the analysis of multi-dimensional geometry and detailed description of fracture network respectively. Also there're some restrictions for further optimized developments for Korean typical hydro-geological system with commercially licensed program.

As a part of the mid- and long-term nuclear research and development program in Korea, KAERI is developing a new probability safety assessment code with a multi-dimensional analysis. A newly developed Multi-Dimensional Probability Safety Assessment (MDPSA) code is capable of probabilistic assessment of radionuclides in multi-dimensional regions both of a fracture network and of a porous medium such as a top soil and buffer and backfill layers.

The fundamental models adopted in MDPSA code for describing topography and fractured-porous medium are described herein briefly and some related results are presented. The brief contents are as follows : For the represent of topography effects inactive blocks are introduced. For the verification of capabilities in describing the fractured-porous medium, complex fracture network located between two porous medium is constructed on the basis of stochastic methods. The radionuclide transport in stochastic fracture network is simulated and the results are compared with that in single fracture. Finally the availability of MDPSA code in simulating fractured-porous medium with simple topography is examined.

2. Methods and Results

2.1 Simulating non-planar top surface

In MDPSA code the domain for the calculations is defined using a cuboid region that covers the domain of interest and is subdivided into cuboid blocks with an overall cubic structure. Within the overall region, each blocks are specified one of the following ones : a porous medium, a fracture-network one or an inactive one. Appropriate modeling would be assigned and processed in a porous or fracture-network medium except inactive one. This approach provides considerable flexibility in describing topography. It allows porous-medium models to be set up with a non-planar top surface. This is achieved by specifying some blocks to be inactive in such a way that the remaining active blocks approximate the desired domain. In this way, MDPSA code can allow models to be set up with non-planar sides, or even with one or more holes in the interior of the domain.

2.2 Radionuclide transport in single fracture

Conventional fracture network model adopted in MASCOT et al. simplifies the fractured-porous medium as a single fracture combining two porous media. For the represent of a radionuclide transport in conventional fracture network model with MDPSA code, a single fracture network is constructed by deterministic method. In MDPSA code a fracture is specified by its position, orientation and size. Depending on the method of generating these data deterministic fracture or stochastic fracture are classified.

Figure 1. shows the concentration distribution in single fracture. Dirichlet boundary condition such as 1.0 for inlet and 0.0 for outlet is applied respectively for radionuclide. As time proceeds, concentration distribution profile becomes flat as expected. In this way a conventionally utilized single fracture linkage between two porous medium is useful for description of few discrete fracture network. However it has some limitations in reproducing complex underground fracture linkages in detail.

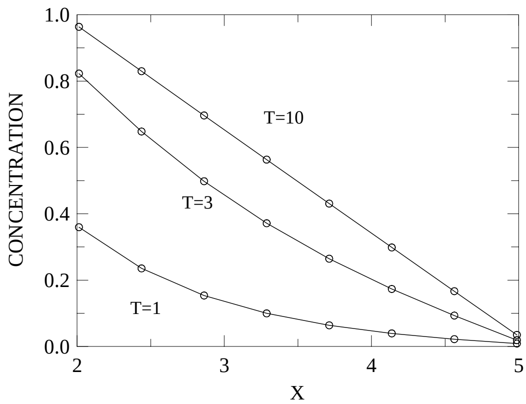


Figure 1. Radionuclide concentration distribution in single fracture

2.3 Radionuclide transport in multiple fracture network

For the more detailed description of complex fracture linkage multiple fracture network can be generated in MDPSA code. Since the related mathematical descriptions have been introduced[4] and the successive publish is on schedule near future, the detailed description is omitted herein.

Figure 2 shows the radionuclide concentration distribution in multiple fracture network. Over 6,600 fractures are generated stochastically and utilized to connect two porous media or fractures. As the same with the result from single fracture, the whole trend with space and time is alike. This shows that multiple fracture network is able to describe the geometry with complex fracture linkage in detail.

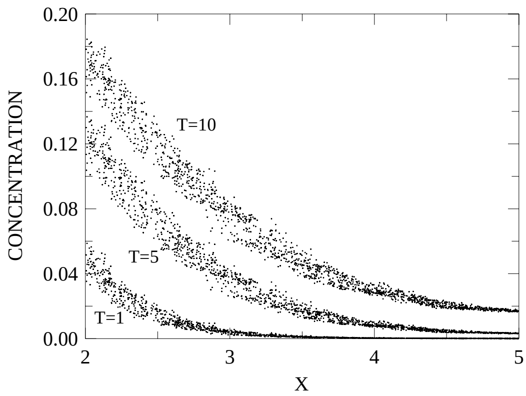
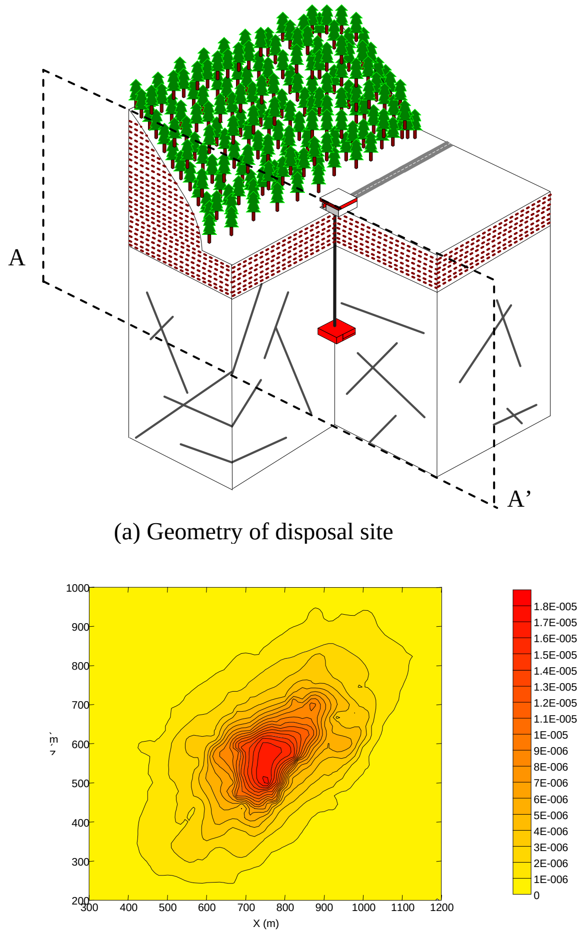


Figure 2. Radionuclide concentration distribution in multiple fracture network

2.4 Representation of radionuclide transport in fractured-porous medium geometry with topography

Based on the prescribed methods radionuclide transport is anticipated in fractured-porous medium geometry with topography. Upper top soil layer is represented as porous medium and mountain is described using inactive block. The lower fracture layer is composed of two kinds of fractures whose inclination is 0 and 60 from horizontal line with counter clock wise. Figure 3.(a) and (b) shows a simple geometry of disposal site and concentration distribution in section AA' respectively. The overall inclination of calculated concentration distribution shows similarity comparing that of fracture distribution. From the calculated results MDPSA code is expected to anticipate the radionuclide transport physically well in real geometry.



(a) Geometry of disposal site

(b) Concentration in section AA'

Figure 3. Radionuclide concentration distribution in fractured-porous medium with topography

3. Conclusion

MDPSA code is successful in representing topography and complex fracture network. Also the availability of MDPSA in dealing with groundwater flow and radionuclide transport in complex fractured-porous medium is verified. MDPSA code is expected to be used as one of the useful tools for the safety assessment of expecting Korean repository for HLW.

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