A Rock Mechanics and Coupled Hydromechanical Analysis of Geological Repository of High Level Nuclear Waste in Fractured Rocks

Ki-Bok Min

Seoul National University, 599 Gwanak-ro, Gwanak-gu, Seoul, 151-744, Korea

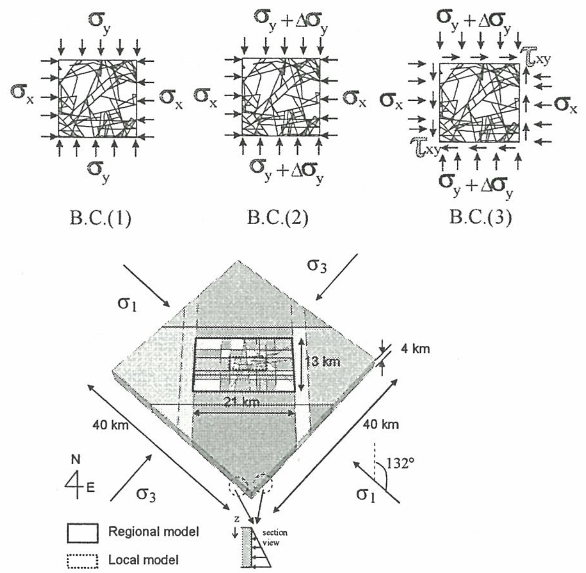
kbmin@snu.ac.kr

1.Introduction

For many countries concerned about the safe isolation of nuclear wastes from the biosphere, disposal in a deep geological formation is considered an attractive option. In geological repository, thermal loading continuously disturbs the repository system in addition to the disturbances induced by repository excavation. This paper introduces a recent development in rock mechanics and coupled hydromechanical study using DFN (Discrete Fracture Network) -DEM (Discrete Element Method) approach mainly applied in hard, crystalline rock containing numerous fracture which are main sources of deformation and groundwater flow.

2.Rock Mechanics Study - Determination of rock mass properties by DFN-DEM approach

The DFN-DEM approach used DFN for the geometry of fractured rock masses and DEM as the numerical technique for the numerical experiments (Min *et al.*, 2004). In determining rock mass properties, this approach can overcome the limitation of empirical approach using rock mass classification in that it can consider the effect of fractures more explicitly, the anisotropy of the rock mass and their stress dependencies. The boundary conditions for such numerical experiments is shown in Fig. 1 (a).



(a)

(b)

Fig. 1 (a) Boundary conditions for numerical determination of elastic constants, (b) Geometry of Oskarshamn area, Sweden, modeled by three dimensional discrete element analysis.

3.Rock Mechanics Study - In situ stress determination aided by discrete numerical modeling

Knowledge of *in situ* stress is critical for the construction of a geological repository for nuclear waste, and *in situ* stress should be taken into account in determining repository site suitability, characterization, and design (Amadei and Stephansson, 1997). One of the difficulties encountered in characterizing *in situ* stress is that it is rarely uniform in a rock mass. The distributions of *in situ* stresses depend largely on the rock mass structure, including discontinuities and the loads applied to the rock mass throughout its entire geological history.

Fig. 1 (b) shows the study about the effect of deformation zones on the measured *in situ* stress at Oskarshamn which was one of the two candidate sites for a geological repository of nuclear waste in Sweden. Attempts have been made to simulate many important large-scale deformation zones that can affect the current state of stress. Furthermore, the modeled state of stress can also provide useful information for the selection of location for the next rock stress measurement campaign.

4. Hydromechanical analysis - Stress-dependent permeability and fluid flow channeling due to stress change

Fig. 2 shows a stress-dependent permeability and notable channelling flow effect caused by stress-induced fracture dilation simulated by DFN-DEM approach. As large shear dilations are concentrated in a smaller part of the fracture population with near-critical orientations, good connectivity, and long trace lengths, the rest of the fracture population, especially the sub-vertical ones, still undergo the normal closures without any shear dilation.

5. Conclusion

This paper introduces a few case studies on fractured hard rock based on geological data from Sweden. Korea is one of a few countries where crystalline rock is the most promising rock formation as a candidate site of geological repository of high level nuclear waste. Despite the progress made in the area of rock mechanics and coupled hydromechanics, extensive site specific study on multiple candidate sites is essential in order to choose the optimal site.

6. ACKNOWLEDGEMENT

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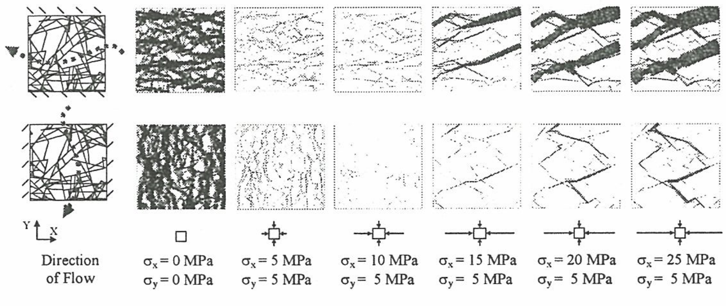

Fig. 2. Enhanced fluid flow due to shear slip from increased horizontal stress modeled by DFN-DEM approach. Shear dilation causes the increase of permeability by a factor of six when the allowable change of aperture is from 5 μm to 50 μm (Min et al., 2004).