Numerical Analysis of Upward Movement of Dummy Canister at Engineered Barrier Emplacement Experiment

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1. Introduction

DECOVALEX-2019 was started with 14 funding organizations in 2016. Since then, seven tasks have been carried out in the project. Korea Atomic Energy Research Institute joined the project as one of funding organizations and participates as a research team for Task A and D. This paper contains the main results of the coupled numerical analyses performed by KAERI within the framework of the DECOVALEX-2019 Task D deals with the coupled interactions in buffer materials [1].

2. Numerical model for EB experiment

The first task is numerical modeling of engineered barrier emplacement experiment (EB) in the DECOVALEX-2019 Task D. The large scale EB experiment was performed at the Mont Terri Underground Laboratory (Fig. 1). The EB experiment is isothermal test to investigate the HM interactions and it was performed for 10.7 years [2]. KAERI research team used TOUGH2-MP/FLAC3D (Fig. 2) to conduct the numerical simulations for the EB experiment.

In this study, 2D dimensional analysis was performed in 20 m wide and 40 m height domain. Initial pore pressure of host rock was set to 1.2 MPa. And sxx and syy were set to 2.5 and 6.0 MPa, respectively. The initial saturation was set to 1.0 at the rockmass. And relative humidity on the tunnel surface was assumed by 93 % and 9.6 MPa suction was assigned on the surface after the excavation. And pore pressure was fixed by 0.1 MPa on the tunnel surface. Based on the information in the Task D description [1], initial suction of pellets and bentonite block are about 450 MPa and 125 MPa, respectively. Therefore, initial Rh of pellets and bentonite block were set to 3.5 % and 40 %, respectively.

Main parameters of hydraulic model are listed in Table 1.

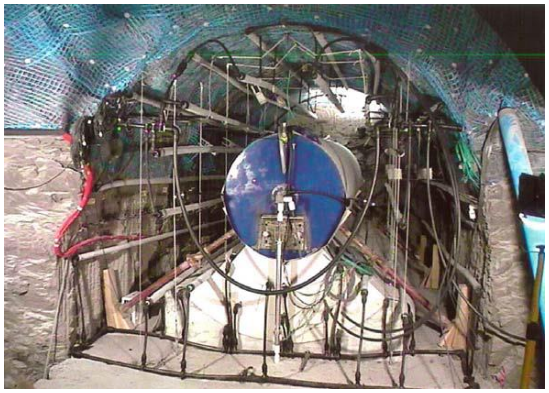

Fig. 1. Pre-conditions of the GBM emplacement [1].

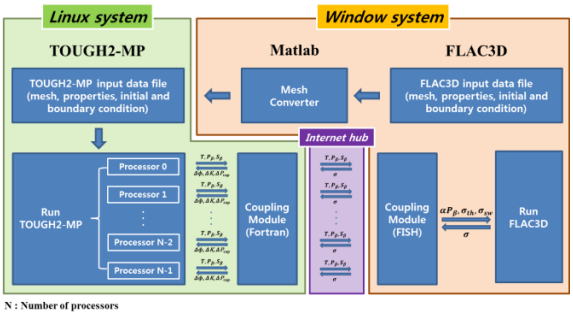

Fig. 2. TOUGH2-MP/FLAC3D coupling module algorithm.

Table 1. Hydraulic parameters of main materials

Parameters	GBM	Bentonite Block	Host rock
Density (kg/m^3)	2,700	2,700	2,700
Porosity (-)	0.496	0.374	0.162
Permeability (m^2)	2.0E-18	5.0E-21	5.0E-20
Relative permeability	$S^{1.9}$	$S^{4.64}$	$S^{3.0}$
λ in van Genuchten model	0.217	0.32	0.401
P0 in van Genuchten model	0.95	30.0	18.0

In this study, generalized power law was used for the consideration of relative permeability (Eq. 1). And van Genuchten model is adopted in this

modeling. For the mechanical analysis, Barcelona Basic Model (BBM) was used for granular bentonite material (GBM) and bentonite block and the used BBM parameters are listed in Table 2.

Table 2. Mechanical parameters for Barcelona Basic model

Parameters	GBM	Bentonite Block
$M\ (-)$	1.5	1.5
$k_s\ (-)$	0.1	0.1
$\kappa_{ps0}\ (-)$	0.06	0.027
$\alpha_{ps}\ (MPa^{-1})$	-0.0015	-0.003
$\kappa_{sp0}\ (-)$	0.05	0.052
$\alpha_{sp}\ (-)$	-0.13	-0.12
$\alpha_{ss}\ (MPa^{-1})$	-0.016	-0.007
$\lambda_{ps0}\ (-)$	0.17	0.18
$R_\lambda\ (-)$	0.6	0.75
$\beta_\lambda\ (MPa^{-1})$	0.05	0.05
$P_0^*\ (MPa)$	1.0	14.0
$P^c\ (MPa)$	0.075	0.1

3. Displacement

Modeling results are plotted with results of in-situ experiment at section A1 in Fig. 3. An upward movement of 10.6 mm was measured in the section A1, because higher swelling potential of bentonite block compared with the lighter pellets. The phenomenon was modeled well in the BBM. And the calculated upward displacement show good agreement with measured data. The upward movement of 11.6 mm was calculated in the modeling.

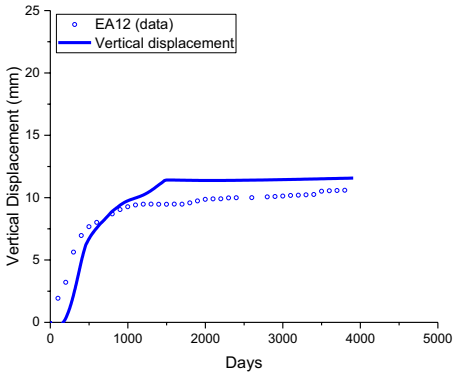

Fig. 3. Vertical displacement of the canister at section A1.

4. Conclusion

TOUGH2-MP/FLAC was used to perform numerical modeling of EB experiment. BBM was used to calculate displacement. Calculated displacement shows good agreement with measured data.

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