Modelling infiltration tests on pelletized bentonite under non-isothermal conditions

Ramon B. de Vaconcelos*º, Antonio Gensº and María V. Villar†

* º Centre Internacional de Mètodes Numèrics en Enginyeria (CIMNE)
Departament Enginyeria del Terreny
Universitat Politècnica de Catalunya
Jordi Girona 1-3, Campus Nord UPC, 08034 Barcelona, Spain
e-mail: ramon.bvasc@gmail.com, antonio.gens@upc.edu
Web page: https://www.etcg.upc.edu/

† CIEMAT
Avenida Complutense 40, 28040 (Madrid)
Email: mv.villar@ciemat.es - Web page: http://www.ciemat.es/

ABSTRACT

Expansive clays (bentonite) are adopted as the main material for high level radioactive waste barriers because of their low hydraulic conductivity, high retention capacity and its ability to fill and seal irregularities, gaps and fractures. In order to fulfil the safety functions of the engineered barrier, the material has to exhibit a sufficient expansion capacity that it is usually characterized in terms of swelling pressure. Swelling pressure developed during saturation is in turn closely related to the dry density of the material; a minimum value to be achieved during installation is usually specified in the design. Pellets-based materials have become an attractive solution for forming engineered barriers and seals. Because of the very high density of the pellets, adequate average dry densities may be obtained even with minimal or no compaction effort.

Thermo-hydraulic infiltration tests under non-isothermal conditions have been performed in the CIEMAT laboratory in Madrid [1] on a granular assembly of pellets made up of pure MX-80 bentonite, a reference material that is being used in the HE-E heating test in the Mont Terri laboratory [2]. Temperature and relative humidity at different points are measured during the test. A fully coupled THM formulation and computer code has been used for the performance of the numerical analyses that tracked closely the various stages of the real experiment. The behaviour of the pellet-based material has been modelled by an elastoplastic model that incorporates the highly swelling characteristics of the bentonite as well as thermal effects.

A good agreement with experimental observations has been obtained over the two years of test duration. In the purely thermal stage without hydration, heating brings about water vapour generation while condensation takes place in the cooler regions leading to an increment of degree of saturation in that part of the experiment. Once hydration starts, relative humidity values tend to increase throughout the column but at different rates depending on the distance to the hydration front. All those THM behaviour features are correctly reproduced by the analyses.

REFERENCES

[1] Villar M.V., Martin, P.L. Gómez-Espina, R., Romero, F.J., Barcala, J.M. 2013. *THM cells for the HE-E test: setup ad first results*. PEBS report D2.2.7a. CIEMAT Technical Report CIEMAT/DMA/2G210/02/2012. Madrid.

[2] Gaus, I., Garitte, B., Senger, R., Gens, A., Vasconcelos, R., Garcia-Sineriz, J.L., Trick, T., Wieczorek, K., Czaikowski, O., Schuster, K., Mayor, J.C., Velasco, M., Kuhlmann, U., Villar, M.V. 2014. *The HE-E Experiment: Lay out, Interpretation and THM Modelling*. Arbeitsbericht NAB 14-53. NAGRA, Wettingen.