ROLE OF HHM COUPLING MECHANISMS ON THE EVOLUTION OF ROCK MASSES AROUND NUCLEAR WASTE DISPOSALS IN THE CONTEXT OF GAS GENERATION

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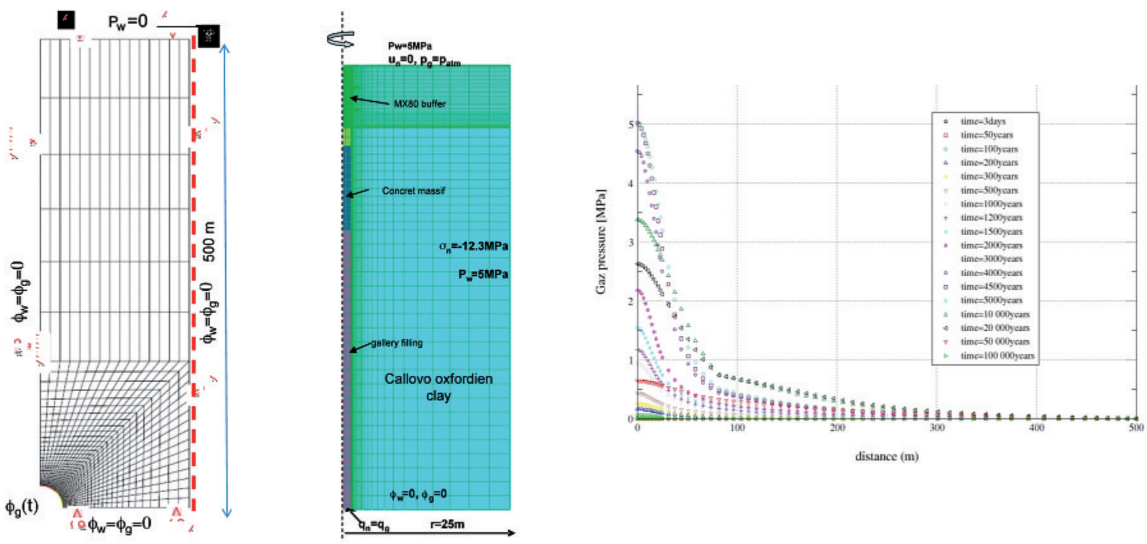
This paper aims at modelling of long term evolution of hydromechanical state of rock masses around sealings nuclear waste disposals. In the principles of nuclear waste disposals the geological barrier must play a long term confining role in respect with nuclide transport. In terms of hydromechanical properties this calls for managing the damage around the underground workings of the waste disposals. In particular the seal buffers and barrier rock will support the generation of hydrogen of different origins, mainly from the corrosion of steals used in various elements of a nuclear waste disposal. This generation would generate gas pressures sufficiently high to partially dry seal or barrier rock leading to a redistribution of stress around underground openings, to a reactivation of the rock damage and finally could put in question the concept of geological barrier itself.

The object of this paper is to shed light in the mechanisms of HHM coupling in rocks around a repository by comparative numerical analyses. Basically, we chose two configurations to proceed with analyses: one in plan strain conditions and the other an axial symmetric configuration (Figure 1.a and Figure1.b). The goal of the first configuration is the assessment of gas pressure evolution in the openings of a repository. The principal input of the problem is the kinetics of gas generation (H_2 generation) given by a step-wise function of time describing the gas generation of one single nuclear waste coli. Then known the repository architecture one could easily calculate the mass of gas generated on one access gallery.



a) b) c)

Figure 1: a) geometry of 2D plan strain problem; b) geometry of axial symmetric problem; c) evolution of gas pressure following cut AA in 2D plan strain problem.

Since extreme scenario is studied, we suppose that the gas generated by the set of alveoli is fully located in the access gallery and only a radial gas flux is possible.The hydro mechanical properties of rocks up to the surface were taken into account. For the callovo – oxfordien clay that constitutes barrier rock in immediate neighbouring of the gallery a model developed on the bases of experimental results have been used ([2]). This model combined in one hand the inviscid plasticity and in the other hand a creep component. The model parameters have been chosen to fit the laboratory results on instantaneous compression tests and uniaxial creep tests. For the upper layers rocks an elastic behaviour is assumed and their poromechanical properties were chosen form laboratory results.

The modelling was performed in the framework of poromechanical theory of multiphase flow taking into account classical hydromechanical coupling of porous media as proposed by an extension of Biot's theory by Coussy 2004. In particularly the gas phases is constituted by H_2 and water vapour, supposed to be perfect gases following the Kelvin law of equilibrium. The Darcy advection, Fick's diffusion and Henry's dissolution are the principal mechanism governing the flow and the exchanges between different phases.

Mainly three kinds of numerical analyses were performed: a) simple two phase flow analyses with no coupling with mechanics (HH analyses); b) coupled hydromechanical analyses with no variation of permeability with damage (HHM-W); c) fully coupled HHM analyses with evolution of permeability as a function of rock damage.

The principal results of these analyses are shortly mentioned hereafter:

– The maximal gas pressure obtained under the conditions and hypothesis of our analyses is inferior of 7MPa.

– There are no significant differences in results (in terms of gas and water pressure and saturation) between HH analyses and HHM-W analyses. As much as the permeability does not evolve the dilatancy of rock (so the variation of the porosity) has a minor role in the variation of pore pressure.

– The principal impact of gas pressure and coupling effects is an amplification of rock damage. However its influence on the creep is limited.

– The mechanics most important role in hydraulics is resumed in the variation of the permeability that could significantly shift the kinetics of gas pressure and water pressure evolution in barrier rocks and buffer.

References:

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