Chemo-mechanical modelling of swelling in a fractured porous medium

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ABSTRACT

In the context of the lifetime extension of nuclear power plants, the french Institut de Radioprotection et de Sûreté Nuclaire (IRSN) conducts researches to predict the ageing of cementitious materials. The present work is focusing on the impact of the chemical degradations such as Delayed Ettringite Formation (DEF) on the overall material properties at the aggregates scale. DEF is an endogenous pathology related to the cement composition and to the early age chemical reactions where thermal conditions induced dissolution of primal ettringite and later moisture environment can lead to ettringite reprecipitation. The crystallization pressure in the porous cement paste thus conducts both to its swelling and some cracking by differential strains. These cracks are preferential location for ions diffusion and further ettringite reprecipitations. These strongly coupled phenomena suggest a non-linear chemo-mechanical modelling where the diffusion, precipitation, pressurization and crack process should be solved in a coupled approach. In an modelling, for each time step, one calculates:

Species diffusion: to describe the environmental impact on the concrete. Diffusion is modeled by Fick's law in a porous medium. This model follows the framework of [1] and it takes into account the resistive impact of the crack on the normal flow;
Chemical reactions: knowing species concentrations in solution, one models different types of reactions such as aqueous, solid and sorption reactions [2]. Thus, the amount of ettringite volume is evaluated;
Mechanical: knowing the solid volume, a local pressure is calculated in the poro-mechanical model and in the cracks. The crack initiation, propagation and pressurization are based on a dedicated Cohesive Zone Model [3].

The presented applications will focus on the impact of material properties, such as volume fraction of inclusion and matrix composition, on strain kinetics.

REFERENCES

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