UNIVERSITÉ DE STRASBOURG

Institut Terre & Environnement de Strasbourg | ITES | UMR 7063

Institut für Strömungsmechanik und Umweltphysik im Bauwesen

Leibniz Universität Hannover

Master Thesis

Modeling hydro-mechanical processes in fractured porous media with the mixed hybrid finite element method: Comparison with OpenGeoSys

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Coupled hydro-mechanical (HM) processes occur frequently and have a significant influence on a number of important engineering applications, such as groundwater management, salt domes, CO2 sequestration, tunnels and dams stability, waste storage, geothermal oil and gas reservoirs. In several applications, the studies on HM processes rely on numerical modelling. However, numerical modelling of these processes is a challenging task (Kolditz et al., 2018). The challenges are related to the large scales in time and space, the nonlinear interaction between the different physical processes, and the heterogonous and anisotropic nature of the domains. The challenges are also connected with the mathematical properties of the governing equations and the limited capacities of existing numerical methods in producing efficient solutions while maintaining high accuracy. Many efforts have been devoted to the development of advanced numerical schemes for the simulation of HM processes in fractured porous media, but this topic is still open in order to improve model realism, accuracy and performance (Miller et al., 2013).

Mixed hybrid finite element method (MHFE) has been shown to be efficient and accurate in simulating fluid flow in fractures porous media (Kohboor et al. 2020). The extended finite element method (XFEM), thanks to its several benefits, has been widely used in solid mechanics to solve problems involving discontinuities (Khoei et al., 2012). Thus, coupling MHFE and XFEM can lead to an efficient and high accurate numerical scheme for the simulation of HM problems. Yet, these methods (MHFE and XFEM) have been never coupled together for solving the equations governing of HM processes. A new numerical model for modeling HM processes in fractured domains has been developed at the “Institut Terre et Environment de Strasbourg“ (University of Strasbourg), by coupling MHFE and XFEM methods. The objective of this master thesis is to validate the newly developed model by comparing it with the finite element model OpenGeoSys. Beside verification, these comparisons allow also for highlighting the advantages of this coupling between MHFE and XFEM methods.

The candidate will stay partially in Hannover/Germany, and partially in Strasbourg/France. The candidate will receive 600 €/month during 5 months from the university of Strasbourg.

References:

1-Kolditz et al 2018. Thermo-Hydro-Mechanical-Chemical Processes in Fractured Porous Media: Modelling and Benchmarking: From Benchmarking to Tutoring, https://doi.org/10.1007/978-3-319-68225-9

2- Miller 2013. Numerical simulation of water resources problems: Models, methods, and trends. https://doi.org/10.1016/j.advwatres.2012.05.008

3-Koohbor et al. 2020. An advanced discrete fracture model for variably saturated flow in fractured porous media. 103602. https://doi.org/10.1016/j.advwatres.2020.103602

4- Khoei 2012. Thermo-hydro-mechanical modeling of impermeable discontinuity in saturated porous media with X-FEM technique. https://doi.org/10.1016/j.engfracmech.2012.10.003