Solving Coupled Problems in the Realm of Fracturing Processes of Saturated and Unsaturated Porous Media

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ABSTRACT

In nature, fracture scenarios occur in saturated as well as in unsaturated porous media, such as soil or rock. Describing these media, fractures in the sense of local instabilities are nearly almost initiated by water, as for example by heavy rainfall events on the one side or by hydraulic fracturing (fracking) scenarios on the other side. Based on the Theory of Porous Media (TPM) [1], bi- and triphasic models are presented as fully or partially saturated porous soil or rock, either filled by a single pore fluid, such as water, or by both a pore fluid and a pore gas, such as air. Based on these models, strongly volumetrically coupled problems occur that have to be handled by the finite-element analysis (FEA).

After an introduction to coupled porous-media problems, the lecture presents fracking processes (mode I fractures) for brittle porous solids under quasi-static and dynamic conditions [2, 3]. This procedure is included in the description by enhancing the TPM through the phase-field approach to fracture [4], where the phase-field variable itself is used for the detection and evolution of single cracks and crack fields that are mainly driven by the pressure of the fracking fluid [2, 3, 5, 6]. In the unsaturated domain, shear-band scenarios (mode II fractures) are additionally discussed for ductile porous soil including porous-media elasto-plasticity.

By use of the solver PANDAS that has been created for the solution of strongly coupled problems in extended continuum mechanics, numerical examples with 2-dimensional and 3-dimensional geometries exhibit the possibilities of the overall procedure [7].

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