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NONLINEAR COMPUTATIONAL HOMOGENIZATION OF PERFUSED POROUS MEDIA USING THE SENSITIVITY ANALYSIS

Eduard Rohan and Vladimír Lukeš

European Centre of Excellence, NTIS New Technologies for Information Society,
Faculty of Applied Sciences, University of West Bohemia,
Univerzitní 8, 30614, Pilsen, Czech Republic
e-mail: rohan@kme.zcu.cz, lukes@kme.zcu.cz

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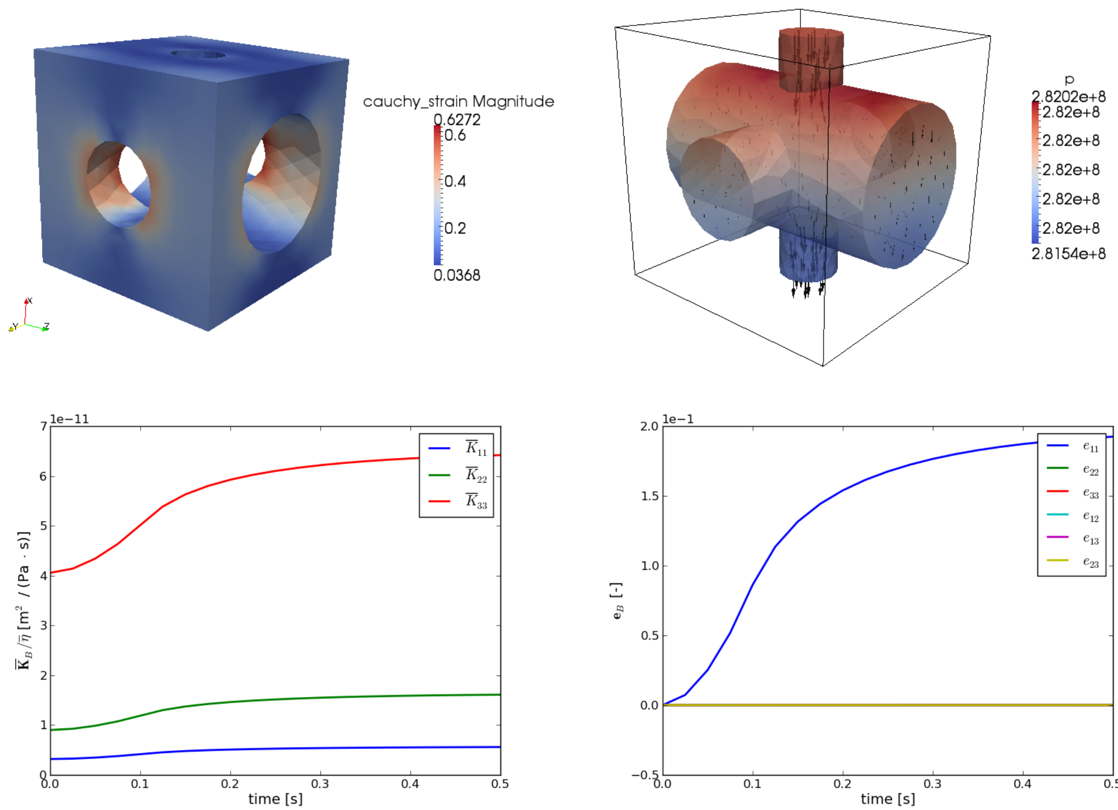
In this paper we consider quasistaic flows in saturated porous media with locally periodic structures. Recently a nonlinear model of the Biot-type poroelasticity was proposed to treat situations when the deformation has a significant influence on the permeability tensor controlling the seepage flow and on the other poroelastic coefficients [2]. Under the small deformation assumption and the first order gradient theory of the continuum, the constitutive laws are considered usually in linearized forms involving material constants independent on the field variables, like deformation, or stress. In this context, our treatment of the material coefficients depending on the stress and deformation state can be viewed as an extension of the first order theory, whereby the linear strain kinematics still holds and the initial domain is taken as the reference. In our approach, the poroelasticity model is derived using the homogenization of the elastic solid skeleton with periodic pores saturated by a weakly compressible static fluid [1], whereby the Darcy flow law is obtained by homogenizing the Stokes flow. Such uncoupled treatment was justified for slow quasistaic processes. To respect dependence of the effective properties on the microstructure deformation, we proposed to use the Taylor expansion w.r.t. the macroscopic variables involved in the global problem. For this, the sensitivity analysis well known from the shape optimization is adopted [3]. The resulting weakly nonlinear formulation involves the effective poroelasticity and permeability coefficients which are linear functions of the macroscopic response.

Then we consider a fully nonlinear model, based on the correct nonlinear kinematics, which has been derived by homogenization of the incremental Updated Lagrangian Formulation. This model brings about several hurdles related to the numerical implementation, as the configuration changes with deforming microstructure.

In numerical examples we compare 3 models: the linear, the quasi-linear with linear kinematics and the nonlinear based on the Large deformation. In the figures (see below) a poroelastic microstructure is depicted; the permeability coefficients change with increasing global strain (inflated structure).



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