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Original article

Multiscale FE simulation of diffusion-deformation processes in homogenized dual-porous media

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Abstract

The paper deals with a model of the homogenized fluid saturated porous material which recently was obtained by the authors using the asymptotic analysis of the Biot type medium characterized by the double porosity. The homogenized macroscopic model is featured by the fading memory effects arising from the microflow in the dual porosity. We derive the steady state formulations and discuss several topics related to the numerical implementation of the model, namely the solution procedure of the discretized microscopic problems, evaluation of the homogenized coefficients and an approximation of the convolution integrals of the macroscopic model, so that the fading memory effects are computationally tractable. Numerical examples are presented to illustrate the approximation schemes discussed in the paper. All computations were performed using the in-house developed finite element code SfePy allowing the multiscale simulations. Besides various potential engineering applications, the present model is intended for simulations of compact bone poroelasticity.

Keywords: Homogenization; Fading memory; Fluid-saturated porous medium; Double porosity; Multiscale simulation

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1. Introduction

Mechanics of porous solids penetrated by fluids is one of the key issues of modern continuum mechanics due to vast applications in geology and mining, in civil and environmental engineering, in biomechanics of tissues and material engineering. In [4], M. Biot formulated the basic theory of deformation of a porous, isotropic, elastic solid which is subjected to a small strain and is saturated by a Newtonian fluid. Then this theory was extended by Biot to an anisotropic elastic fluid-saturated medium where all the constituents can be compressible. The detailed description of the poroelastic theory can be found, for example, in the book of [8], whereas the development of the theory from the very origins in the nineteenth century is traced, e.g., in [10].

Typically the porous media are characterized by several scales at which different porosities appear. This provoked a class of models featured by the so-called *dual porosity* [1–3]. In the context of asymptotic analysis of the given type of

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