On the solution of coupled porous media mechanics with hysteretic liquid retention behaviour

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ABSTRACT

Solid-fluid coupled porous media behaviour can be rationally and conveniently represented by the Theory of Porous Media (TPM) [1, 2]. For partially saturated media, the resulting system of equations is highly nonlinear due to the liquid retention behaviour. Moreover, the hysteresis that arises from cycles of drainage and imbibition further adds to the complexity of the coupled formulation. The robust solution of this problem is therefore much desired in view of the wide range of applications of the TPM.

This contribution presents a finite element solution to the dynamics of porous media *via* TPM with a consistent treatment of the liquid retention hysteresis. A simple u-p (u: displacement of solids; p: pressure on liquid) formulation is proposed where the time discretisation is carried out prior to the space discretisation. Time integration is approximated with the Theta and Newmark's methods. Versatile models for the liquid retention and conductivity behaviours, based on the concept of references [3], are discussed and implemented.

It is shown that a stable and efficient solution can be obtained by means of a classical implicit formulation with Newton's method for the nonlinear problem. By first applying Theta and Newmark's method (time discretisation), all consistent derivatives can be deduced; these are essential for quadratic convergence. In particular, it is shown that the liquid retention model requires also the consistent second-order derivative for rapid convergence. Some predictive simulations are presented and illustrate the capabilities of the formulation; specifically they highlight the ability to model complex porous media behaviour [4].

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