

Theory of Finite Deformations of Porous Solids

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1. Introduction. The linear mechanics of fluid-saturated porous media as developed by the author was reviewed and discussed in detail in two earlier papers [1], [2]. In its final form it is based on the linear thermodynamics of irreversible processes. It is applicable to the most general case of anisotropy and includes not only the basic principles of classical thermodynamics but also the effects of coupled flows of irreversible processes. Thermoelastic dissipation is also implicit since the heat flux is nothing but one of the internal thermodynamic coordinates of the system. The solid matrix itself may be viscoelastic. Actually the theory is even more general since it takes into account the viscoelastic interaction of the fluid with the solid due to the micromechanics of fluid penetration in cracks which are much smaller than the pores. An important concept derived from the existence of a dissipation function for the fluid is that of "Viscodynamic operator" [2]. This is an operational symmetric tensor which describes the frequency-dependent behavior of the fluid. The symmetric character of this tensor leads to important conclusions in the theory of acoustic propagation.

Regarding the extension to non-linear problems a first step is constituted by a theory which introduces the non-linear superposition of a state of initial stress and incremental deformations [3]. This also leads to an analysis of finite deformations based on stress-rates. In this case the deformation is considered as a continuous sequence of incremental deformations [4]. The concepts and methods introduced in this incremental theory lead quite naturally to the next development which considers a description of finite deformation using material coordinates. In particular the concept of pressure function for a porous medium which was introduced in the theory of incremental deformations [3] provides one of the essential means by which this extension of the theory can be accomplished. The mechanics of porous media is thus brought to the same level of development of the classical theory of finite deformations in elasticity. In order to restrict the length of the paper, the theory is presented in the context of quasi-static and isothermal deformations.