Nonlinear and Semilinear Rheology of Porous Solids.

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Abstract. The nonlinear and semilinear mechanics of porous solids is developed in terms of the Cartesian definition of finite strain and a local rotation field. It is based on modern developments in irreversible thermodynamics and viscoelasticity. This particular approach provides a method of introducing an essential feature of porous solids referred to here as semilinearity. The linear behavior is represented by a linear dependence of the volume of the individual grains on stresses and pressure. The nonlinear behavior is then mainly a consequence of local geometric effects such as changes in contact areas, crack closure, etc. Under these conditions it is shown that seven physical constants describe the semilinear properties of an isotropic porous solid. Viscoelastic behavior is analyzed in the semilinear context, and a plastic flow condition is also formulated in terms of the effective stress. Nonlinear equations for the displacement field are derived in which a Cartesian representation is used. The equations are found to be relatively simple and are directly applicable to semilinear materials. It is also shown how the present Cartesian semilinear formulation leads to variational principles and Lagrangian equations that bring the theory within the more general framework of modern developments in nonlinear irreversible thermodynamics.