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Cam-Clay plasticity, Part VIII: A constitutive framework for porous materials with evolving internal structure

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Summary. Natural geomaterials often exhibit pore size distributions with two dominant porosity scales. Examples include fractured rocks where the dominant porosities are those of the fractures and rock matrix, and aggregated soils where the dominant porosities are those of the micropores and macropores. We develop a constitutive framework for this type of materials that covers both steady-state and transient fluid flow responses. The framework relies on a thermodynamically consistent effective stress previously developed for porous media with two dominant porosity scales. We show that this effective stress is equivalent to the weighted sum of the individual effective stresses in the micropores and macropores, with the weighting done according to the pore fractions. This partitioning of the effective stress into two single-porosity effective stresses allows fluid pressure dissipation at the macropores and micropores to be considered separately, with important implications for individual characterization of the hardening responses at the two pore scales. Experimental data suggest that the constitutive framework captures the laboratory responses of aggregated soils more accurately than other models previously reported in the literature. Numerical simulations of boundary-value problems reveal the capability of the framework to capture the effect of secondary compression as the micropores discharge fluids into the macropores.

Keywords: coupled problem · double porosity · effective stress · mixture theory

1 Introduction

Many natural geomaterials such as aggregated soils and fissured rocks exhibit pore size distributions with two dominant values of porosity [1, 2, 26, 28, 31, 55]. In fissured rocks the two scales of porosity are those of the rock matrix and fractures [11, 61, 64, 68, 74, 77, 79, 83], whereas in aggregated soils,