A Two-scale Poroplasticity Approach to Soil Liquefaction Analysis

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Abstract

Accurate numerical simulation of soil liquefaction and its effects on geo-structures that contain liquefiable soils remains a major challenge in engineering practice. The main ingredients of a rigorous numerical simulation are: 1) a well calibrated constitutive model that allows for accurate modeling of soil's stress-strain-strength behavior over a wide range of stresses and strains, under both monotonic and cyclic loading conditions, and in pre-and post-failure conditions that may occur in the geo-structure containing a liquefiable soil, 2) a theoretical and computational platform that is capable of handling both the pre- and post-failure conditions. In this paper a two-scale elastoplastic model and a micropolar poroplasticity framework is developed and described in details. The model is designed to capture both macroscopic and microstructural features of the soil response. A fully-coupled finite element approach based on micropolar poroplasticity is used to facilitate the modeling of various drainage conditions within the soil.

Through a number of numerical examples, the proposed constitutive model and theoretical framework are shown to reproduce the salient features of the response of soils subjected to cyclic loading in drained, undrained, and partially drained conditions. The ability of the proposed constitutive model and the developed computational framework in capturing the response of soils during cyclic mobility will be demonstrated.

Keywords: Constitutive Model, Liquefaction, Micropolar, Poroplasticity, Two-scale Modeling.