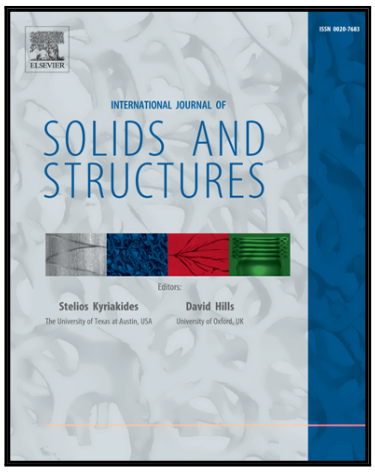

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A THERMODYNAMICALLY CONSISTENT MODEL ACCOUNTING FOR VISCOPLASTIC CREEP AND ANISOTROPIC DAMAGE IN UNSATURATED ROCKS

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Abstract: This paper presents a new poro-viscoplastic damageable model for partially saturated rocks. The hydromechanical modelling is based on the framework of mixture theory for multiphase porous media combined with Continuum Damage Mechanics. The proposed dissipative evolution laws are governed by an effective stress variable, which is a function of an equivalent pore pressure. The viscoplastic creep law is an extension of Lemaitre's model incorporating pressure-dependency and a non-associated flow rule. A new anisotropic damage evolution law for unsaturated rocks under compressive stresses is suggested. Despite a large number of coupled phenomena involved, the model remains relatively simple with a quite moderate number of parameters, while still ensuring the thermodynamic consistency. The model is capable to describe the main features of the time-dependent behaviour of rocks such as strain hardening, stress-dependent creep, moisture effects, damage-induced anisotropy and failure. Its efficiency is evidenced by simulating a number of laboratory tests performed on different rocks.

Key words: Constitutive Modelling; Unsaturated Rocks; Time-dependent; Poromechanics; Anisotropic Damage; Viscoplastic; Thermodynamics;

1. Introduction

Assessing the delayed deformation of rocks is at the core of a broad range of rock mechanics and rock engineering applications, for instance tunnel construction, petroleum extraction or geological disposal facilities design (Paterson, 1978) (Hoek, 1993) (Giraud & Rousset, 1996) (Debernardi & Barla, 2009) (Bui, et al., 2014). The time-dependent behaviour of rocks depends on many factors such as mineralogical and structural features and may originate from different complex mechanisms, including crystal dislocation, diffusion creep and especially microcracking (Carter, et al., 1990) (Boukharov, et al., 1995). The first two mechanisms are often accompanied by a relatively small to moderate amount of deformation, while the latter often imply, after a certain period, a large volume expansion and consequently failure of rock sample.