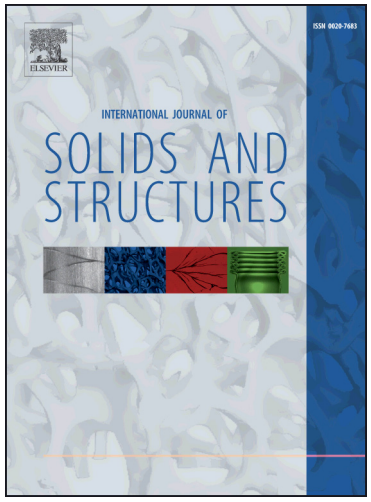

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Modeling of deformation and localized failure in anisotropic rocks

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ABSTRACT

This paper deals with description of the deformation process in argillaceous rocks that display a strong inherent anisotropy. Both, the homogeneous and the localized deformation modes are considered. The effects of anisotropy are incorporated by invoking the microstructure tensor approach. The strain localization is assumed to be associated with formation of a macrocrack the orientation of which is defined using the critical plane approach. The propagation of damage is traced within the context of a boundary value problem by employing a constitutive law with embedded discontinuity. The crack path is monitored in a discrete manner by using the level-set method. The closest-point projection algorithm is developed for the integration of the constitutive relations at both stages of the anisotropic deformation process, i.e. the homogenous mode as well as that involving an embedded discontinuity. The problem of macrocrack formation in a biaxial plane strain compression test is studied. It is demonstrated that friction between loading platens can play an important role in the process of evolution of damage and may significantly affect the compressive strength.

Keywords: Constitutive modeling, anisotropy, localization, discrete crack propagation, embedded discontinuity

1. Introduction

Many geomaterials display a structural anisotropy which is closely related to their microstructure. The primary focus here is on the sedimentary rocks formed by compaction, cementation or crystallization of successive layers of deposited material. These rocks, which include shale and slate, are characterized by the presence of closely spaced bedding planes and exhibit a strong directional dependence of strength as well as deformation properties. The understanding of the mechanical behaviour of argillaceous rocks is of a significant importance due to their widespread applications in many types of geotechnical projects, including petroleum extraction, carbon dioxide sequestration as well as a deep geological disposal of radioactive waste. The primary concern in this case is the onset and propagation of damage due to excavation, transport of pore fluids and/or the elevated temperature.

The description of the mechanical behaviour requires, first of all, the specification of conditions at failure under an arbitrary stress state. In addition, a general framework must be provided for the evaluation of the deformation field, which may include discontinuities such as macrocracks. Over the last few decades, an extensive research effort has been devoted to modeling of the mechanical behaviour of anisotropic rocks. A comprehensive review on this

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