Second gradient hydro-mechanical formulation in saturated conditions using Isogeometric analysis

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Abstract

During the last decade, Isogeometric Analyisis (IGA) has been efficiently used in different fields of computational mechanics [1]. In the framework of porous media, IGA offers an alternative numerical tool to classical Finite Element Method, especially when modeling strain localization phenomena that take place in failure processes in the form of shear bands. Among its different properties, the implicit inter-element higher continuity of IGA stands out when using regularization techniques to ensure objective results in terms of mesh dependence. Furthermore, the number of degrees of freedom reduces drastically due to the fact that not additional constrains such as Lagrange multipliers are introduced to fulfill requirements of continuity in the first derivatives in the finite element formulation, which is of fundamental importance when modeling three-dimensional problems.

The goal of this work is to use the higher order continuity of IGA in the framework of second gradient models [2] that belong to the family of continuum with microstructure, with applications to hydro-mechanical problems in saturated porous media. The mechanical description of the solid skeleton consists of two uncoupled constitutive laws. An advanced three-invariant isotropic hardening elastoplastic model [3] is used for the classical part. For the second gradient part, an isotropic linear elastic relationship has been developed following the ideas in [4], which is a particular case derived from the general expression given by Mindlin [5]. And Darcy's law is assumed for the fluid flow description.

An initial boundary value problem consisting in a square footing consolidation problem is simulated in order to study the effectiveness of the second gradient model in zones with high strain fields as well as the smoothness properties that IGA inherently provides when modeling strong hydraulic gradients.

Keywords: **Strain localization, second gradient regularization, isogeometric analysis, hydro-mechanical coupling**

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