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Shuai Yang, Liping Wang, Shuqin Zhang

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Conformable derivative: Application to non-Darcian flow in low-permeability porous media

Shuai Yang[a,*], Liping Wang[b], Shuqin Zhang[b]

[a] School of Mechanics and Civil Engineering, China University of Mining and Technology, Beijing, 100083, P.R. China
[b] School of Science, China University of Mining and Technology, Beijing, 100083, P.R. China

Abstract

The conformable derivative is used to develop the Swartzendruber model for description of non-Darcian flow in porous media. The proposed conformable Swartzendruber models are solved employing the Laplace transform method and validated on the basis of water flow in compacted fine-grained soils. The results of fitting analysis present a good agreement with experimental data. Furthermore, sensitivity analyses are carried out to illustrate the effects of related parameters on the conformable Swartzendruber models.

Keywords: Conformable derivative, non-Darcian flow, Swartzendruber model

1. Introduction

Khalil et al. [1] proposed a new derivative with real orders, called conformable derivative. Due to its well-behaved properties and the close relationship with first order derivative, conformable derivative has exerted a tremendous fascination on researchers [2, 3, 4, 5]. Furthermore, due to its important applications in various field such as Newton mechanics [6], quantum mechanics [7], arbitrary time scale problems [8], chaotic system [9], stochastic process [10] and diffusive transport [11, 12, 13], the interest in the conformable derivative has been increasing in the recent years. Most recently, Zhou et al. [11] mentioned the conformable derivative approach to non-Darcian flow in low-permeability porous media. It is worthwhile to explore more theoretical and experimental results in this field.

Generally speaking, water flow in low-permeability porous media such as clay could have low velocities and exist threshold hydraulic gradient [14, 15, 16]. It deviates from the the Darcy's linear law and presents a nonlinear relationship between flow velocity and hydraulic gradient, called non-Darcian flow [17, 18]. Much efforts have been contributed to the description of non-Darcian flow, and most of the presented results are based on nonlinear formulas such as power function [19, 20], exponential function [15], incomplete Gamma function [21, 22] and fractional derivative approach [23].

*Corresponding author.
Email address: haotianwuji2@sina.com (Shuai Yang)