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George Z. Voyiadjis, Wojciech Sumelka

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Brain modelling in the framework of anisotropic hyperelasticity with time fractional damage evolution governed by the Caputo-Almeida fractional derivative

George Z. Voyiadjis[a], Wojciech Sumelka[b]

[a]Boyd Professor, Department of Civil and Environmental Engineering,
Louisiana State University,
Baton Rouge, LA 70803, USA
[b]Poznań University of Technology, Institute of Structural Engineering,
Piotrowo 5 street, 60-965 Poznań, Poland

Abstract

In this paper the human brain tissue constitutive model for monotonic loading is developed. The model in this work is based on the anisotropic hyperelasticity assumption (the transversely isotropic case) together with modelling of the evolving load-carrying capacity (scalar damage) whose change is governed by the Caputo-Almeida fractional derivative. This allows the brain constitutive law to include the memory during progressive damage, due to the characteristic time length scale which is an inherent attribute of the fractional operator. Furthermore, the rate dependence of the overall brain tissue model is included as well. The theoretical model is finally calibrated and validated with a set of experimental data.
Keywords: brain model; Caputo-Almeida derivative; fractional damage; memory; anisotropic hyperelasticity.

1. INTRODUCTION

The main inspiration for mathematical modelling of human brain tissue (HBT) are the results obtained from experimental studies. In order to emphasize the most important mechanical properties of HBT one should mention the papers by: Fallenstein (Fallenstein et al.

Email addresses: voyiadjis@eng.lsu.edu (George Z. Voyiadjis), wojciech.sumelka@put.poznan.pl (Wojciech Sumelka)