20th European Mechanics of Materials Conference - EMMC20
Florence, Italy | May 27th-29th, 2026
www.emmc20.unifi.it

Can Energy Outcomes from Uniaxial and Equibiaxial Tests Be Compared? Theory and Experiments

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Paper ID: 508
Symposium S7: Mechanics of soft materials and structures

Abstract

The identification of constitutive response functions for material characterization based on experimental data remains a challenging issue in solid mechanics, particularly when constitutive responses identified from different experimental tests and loading conditions are compared. For homogeneous isotropic hyperelastic materials, experimental results depend on the specific test configuration and test parameters. In this context, the development of a systematic characterization frameworks is essential. This work proposes a novel framework for the experimental characterization of homogeneous isotropic hyperelastic materials, aimed at ensuring consistency in the identification of constitutive response functions. The methodology is formulated both in terms of principal strain invariants and exploits an invariant set that enables an orthogonal representation of the constitutive responses. This representation allows experimental data obtained under different loading conditions to be mapped onto the same kinematic path in the invariant space, where the corresponding response functions are expected to be identical. Within this framework, the different types of experimental tests under homogeneous deformations are systematically discussed, and their mutual compatibility is examined. As a result, constitutive responses identified

from different experimental tests can be directly compared. This classification provides a rational basis for the design of experimental campaigns that enable the consistency of experimental results obtained from different test configurations. In addition, a criterion for the definition of the test speed in experimental campaigns is introduced, and its influence on the experimentally identified response functions is critically examined, highlighting its role in the reproducibility of the characterization process. The proposed framework is assessed through uniaxial and equibiaxial experimental tests where the implementation and strength of the criterion is assessed. The resulting response functions are compared with those obtained using different loading rates.

Keywords:

Hyperelastic material Homogeneous deformations Equibiaxial test Uniaxial test Criscione invariants