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

Full-Field Inverse Identification of Linear Viscoelastic Properties Using EUCLID: Bridging Theory to Experimental Practice

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Paper ID: 611
Symposium S18: Advanced modelling techniques: Data-driven mechanics of materials
Extended Abstract

Abstract

The EUCLID (Efficient Unsupervised Constitutive Law Identification and Discovery) framework has shown remarkable success in numerical studies for automated constitutive model discovery. Previous EUCLID implementations for linear viscoelasticity employed a frequency-domain formulation with a plane strain assumption, creating suboptimal conditions for the experimental setting. Specifically, oscillatory loading at multiple frequencies is challenging to implement while maintaining full-field optical measurements, and plane strain conditions require impractically thick specimens. Furthermore, idealized numerical assumptions, such as perfect boundary conditions and uniform temporal sampling, cannot be reproduced during experiments. This work addresses these gaps by reformulating EUCLID for time-domain creep testing and systematically investigating design parameters that critically influence the material identification process. Our primary contribution is a comprehensive numerical framework establishing practical guidelines for EUCLID experimental validation. We reformulate the linear viscoelastic inverse problem of in the time domain, under the plane stress assumption. A generalized Maxwell model is used to represent constitutive equations in terms of Prony series. The redundant linear system is solved with Non-Negative Least Squares (NNLS) techniques, which exploit the inherent positivity of relaxation parameters. This time-domain approach enables standard creep testing, making it suitable for Digital Image Correlation (DIC) measurements on realistic specimens. Through extensive numerical simulations, we first quantify the impact of mesh density and the effect of specimen topology on the identified viscoelastic parameters. Our investigation reveals that heterogeneous, topology-driven, stress-strain fields are fundamental in the identification process. Especially, it unveils important information concerning the choice of the optimal scaling factor, weighting interior versus boundary nodes, based on the topology of the specimen and the expected compressibility of the material. We also establish how temporal discretization affects inverse problem across multiple time scales, providing useful guidelines on the choice of the sampling frequency based on expected relaxation times of the material. Finally, we systematically assess realistic experimental imperfections: measurement noise propagation, spatial resolution limitations, boundary condition uncertainties when DIC regions cannot extend to actual constraints, variable recording frequencies with inconsistent time intervals between measurements, and geometric tolerances in specimen fabrication where perforation accuracy affects strain field distribution. These investigations establish concrete requirements for experimental data quality and identify which design modifications meaningfully improve identifiability. This comprehensive numerical framework enables EUCLID's transition from computational validation to laboratory implementation. Our ongoing experimental program on viscoelastic materials applies these guidelines to real-world testing, demonstrating EUCLID's potential as a practical tool for full-field material characterization in the experimental mechanics community.

Keywords:

Viscoelasticity EUCLID Material identification