NON-LINEAR VISCOELASTIC-VISCOPLASTIC CONSTITUTIVE MODEL FOR EPOXY POLYMERS

RIGHT RESULTS. AWAY.

OVERVIEW

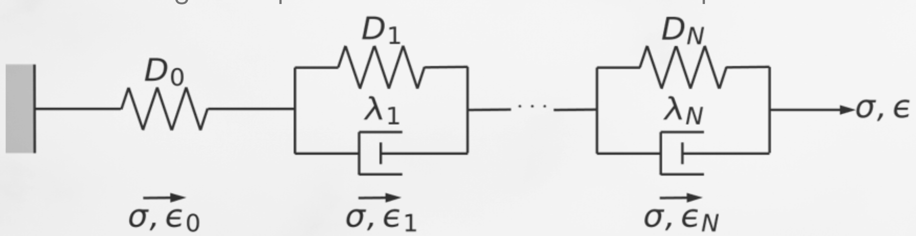
Deployable composite booms for space structures must maintain high performance despite long-term storage and repeated deployment cycles. However, thin-ply high strain composites (TP-HSCs) experience mechanical degradation due to viscoplastic deformation and stress relaxation in the epoxy matrix. This study develops a nonlinear viscoelastic-viscoplastic constitutive model to predict the mechanical behavior of epoxy polymers more accurately.

This model captures the stress-dependent viscoelastic and viscoplastic behaviors of epoxy polymers and enables the prediction of long-term deformation and structural integrity. It provides a foundation for the improved design and reliability of deployable space structures.

KEY BENEFITS

TECHNICAL APPROACH

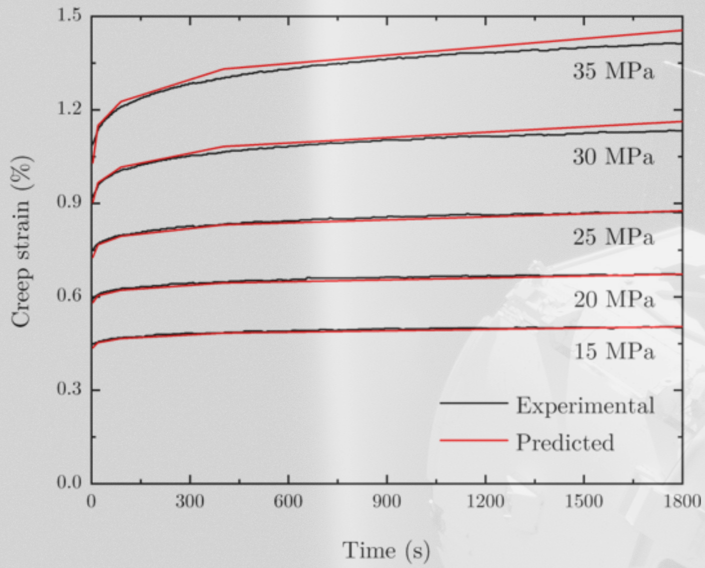
The nonlinear viscoelasticity model is reformulated to yield a closed-form incremental relation, allowing for an accurate and efficient numerical implementation. A viscoplasticity model is developed based on the Drucker–Prager yield function with isotropic and kinematic hardening and a Perzyna-type viscosity function. A radial return algorithm is implemented to solve the viscoplastic flow rule, and an algorithmic tangent operator is derived for computational efficiency.



1D generalized Kelvin–Voigt model

RESULTS

The viscoelastic model successfully reproduces experimental data for polymethyl methacrylate (PMMA). The viscoplasticity model demonstrates strong capabilities in capturing rate-dependent hardening and stress relaxation. Creep-recovery responses of epoxy materials are accurately predicted, validating the effectiveness of the approach.



Experimental and predicted creep responses of PMMA

APPLICATIONS

This model has applications in aerospace engineering, particularly for deployable composite booms in space structures. It can be used in structural engineering for predicting long-term deformation behavior and is valuable in material selection and processing optimization in the manufacturing industry.

FUTURE DIRECTIONS

Future work includes incorporating the model into finite element simulations for large-scale structural analysis, extending the model to include more sophisticated viscoelasticity and viscoplasticity mechanisms, and investigating the applicability of the model to a broader range of polymeric materials. Please contact us for additional information, free trial licenses, or to explore collaboration opportunities.

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