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The contribution of mechanical interactions to the constitutive modeling of fiber-reinforced elastomers. (English) Zbl 07305826

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Summary: Hyperelastic fiber-reinforced materials are conventionally modeled based on the contributions of their constituent materials. A unified invariant-base constitutive model, named Matrix-Fiber-Interaction (MFI) model, is proposed to take into account particularly the mechanical interaction contribution of the constituent materials in fiber-reinforced elastomers with two fiber families. Its high predictive capability for the modeling of the behavior of composites with different material anisotropy is verified by several experiments. This model along with its structurally based framework of material characterization allows measuring distinct contributions of the matrix, fiber, and mechanical interactions in the sense that the latter can be determined regardless of the functional form of the fiber potential. Therefore, in this paper, the MFI model implemented in a user-defined subroutine is used to highlight the importance of mechanical interaction potential. Using three representative examples: uniaxial extension of single-layer plates with different material anisotropy, inflation-extension of a thin cylindrical tube, and load-coupling behaviors in composite laminates, its effect is analyzed. The comparisons of experiments with simulation results underline the prediction quality improvement using the interaction potential in the modeling of single-layer composites. For the two latter deformations, the simulation results comparatively indicate the effect of mechanical interaction potential for the modeling of more complicated structures.

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