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ABSTRACT:

Experimental Investigation of Creep Behavior in Short Fiber-Reinforced Polymers at Different Scales

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Short fiber-reinforced polymers (SFRPs) are increasingly utilized in structural applications due to their high strength-to-weight ratio. However, their complex time-dependent deformation behavior poses significant challenges for lifetime prediction. This study presents a comprehensive experimental investigation into the creep behavior of both unfilled and short fiber-reinforced thermoplastics across multiple length scales to characterize the influence of the reinforcement phase on material consistency. At the meso-scale, creep characteristics were evaluated using grid-based nanoindentation. The results indicate that the pure, unreinforced polymer matrix exhibits a highly homogeneous creep parameter distribution across the specimen cross-section. In contrast, the fiber-reinforced material shows significant spatial scattering of creep properties. This heterogeneity suggests that the local presence and proximity of fibers significantly alter the viscoelastic response of the surrounding matrix. To evaluate the impact of these findings on structural performance, macro-scale creep tests were performed using standard tensile specimens integrated with digital image correlation. While the unreinforced polymer showed a uniform strain distribution, the reinforced composite displayed distinct local variations in creep strain. These macroscopic fluctuations correlate with the meso-scale findings, indicating that the material properties are not constant throughout the volume. The study concludes that the observed scattering at both meso- and macro-levels is fundamentally rooted in the stochastic microstructural properties of SFRPs, such as local fiber orientation and volume fraction. These micro-level uncertainties propagate through the scales, necessitating a probabilistic approach rather than deterministic models for the accurate long-term assessment of reinforced polymer components.