Tuning HMC to enhance Impact Resistance, Fracture Toughness, and Damping in Compliance with Standards for Safety and Performance Metrics

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The vision of this research activity is integration of multi-phase polymeric matrices into high-strength fibrous systems to produce an advanced lightweight composite system that has high-strength sustainability and enhanced energy dissipation. The goal is to develop a methodology that allows structural systems to be designed to meet specific optimal performance and safety metrics based on the ability of the manufactured composite to achieve desired designable properties. This “materials by design” philosophy is formulated in multiple stages, which comprise the multi-scale model.

First, a unique multi-phased polymeric matrix, hybridized at the polymer interface, is analyzed at the chemical bond level. The interfacial cohesion properties are also examined. Secondly, material micro-structural analyses are used to examine the micromechanical properties, such as the reduced elastic modulus and viscoplastic creep. Finally, the system is assembled at the macro-mechanical level, making it applicable to a host of engineering systems, completing a shift in traditional engineering design paradigms through this unique polymeric hybridization. Designable properties include damping, impact resistance, fracture toughness, and modulus of toughness - all formulated within a framework of achieving high-strength sustainability and energy dissipation – which are “tailored,” or “tuned,” to comply with specific high-performance metrics, safety, and comfort-ability standards in various structural systems. The strategy for developing this research is a series of experimental tests to validate the sequential analytical models at various dimensional scales. This enables a thorough understanding of the underlying mechanisms that control the interfacial cohesions and material micro-structures that ultimately affect the performance of the actual structural system. The outcome is the design of various engineering systems to satisfy optimal safety and performance standards.

A ‘materials by design’ philosophy: a multi-scale model for designable high-strength sustainability materials having “tunable” properties controlled by a unique epoxy-polyurea interface