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“A Preliminary Idea of Bio-Inspired Wind Turbine Blade Structures”

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Abstract

Wind turbine blades (WTB) are fabricated from polymeric fiber-reinforced composites with epoxy matrix and glass fibers. The complex service conditions of these structures require a reliable material performance under mixed mode loadings. In the beginning, helix notched cylindrical specimens were used to characterize the fracture resistance of the epoxy matrix. Both optical and scanning electron microscopy (SEM) techniques were used to examine the fracture surfaces for samples failed in both modes I and mixed mode scenarios. Finite element models were also developed to extract energy release rates upon fracture for epoxy samples. Then, effects of fiber orientations and loading rates on failure loads were studied for composite helix notched cylindrical samples. Characterization from microscopy techniques revealed that interfaces between epoxy and glass fibers were critical for composite performance. Effects of fiber orientations on fracture resistance were also reflected on stress contours around crack tips in finite element analysis.

By learning from bamboo, a composite in nature, we may develop ideas for future WTB research. In the bamboo cross section, the ratio of vascular bundles to the matrix decreases from the outside to the inside surface. This ratio variance was correlated to local gradients of elastic moduli and tensile strength using nano-indentation and micro-tensile experiments. Results from four point bending tests revealed that the local fracture toughness increases in the same direction. Good agreement is achieved between fracture resistance predictions from analytical fracture models, finite element models and mechanism-based crack bridging models. Based on the above studies, a preliminary idea of bio-inspired wind turbine blade structure is proposed.

Biography

Dr. Ting Tan is an Assistant Professor in Civil and Environmental Engineering at the University Of Vermont (UVM). He earned a BS in Civil Engineering from Huazhong University of Science and Technology (HUST) in 2003. After serving as an engineering intern in the China Railway Bridge Institute, he returned to HUST for graduate studies and received his MS degree in 2006. He obtained his PhD degree in Civil and Environmental Engineering at Princeton University in 2011. After that, he worked as a postdoc research associate in the U.S. Department of Energy, Oak Ridge National Laboratory before joining UVM in the fall 2012. His research focuses on studying the fundamental failure mechanisms of materials with a synergy of energy and sustainability.

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