Learning from Nature: Designing and Manufacturing High-Performance Composite Structures

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Nature provides many examples of materials that achieve excellent mechanical performance through the efficient organization of relatively simple constituents. Biological materials such as wood, bone, bamboo, and shells exhibit hierarchical architectures, spatially varying properties, and carefully arranged reinforcing elements. These features enable combinations of strength, toughness, flexibility, and damage tolerance that are difficult to reproduce in engineered materials.

This presentation will review recent developments in bioinspired composite materials, focusing on how structural principles observed in nature can be translated into engineered materials. Particular attention will be given to the effects of fibre orientation, reinforcement architecture, and hierarchical organization on mechanical performance. Examples from the literature will illustrate how these principles have been applied to improve material efficiency and structural functionality.

The role of advanced manufacturing technologies in realizing complex material architectures will also be discussed. Additive manufacturing offers opportunities to control reinforcement placement, material distribution, and structural geometry, although challenges related to material selection, fibre–matrix bonding, and consolidation remain. Selected examples from our research on continuous fibre-reinforced thermoplastic composites will illustrate some of these opportunities and challenges.

Finally, the presentation will highlight research activities and capabilities at the Laboratory of Engineering Materials at the University of Calgary, with the aim of encouraging scientific exchange and exploring opportunities for student involvement and future collaborations in the design and manufacturing of advanced composite materials.