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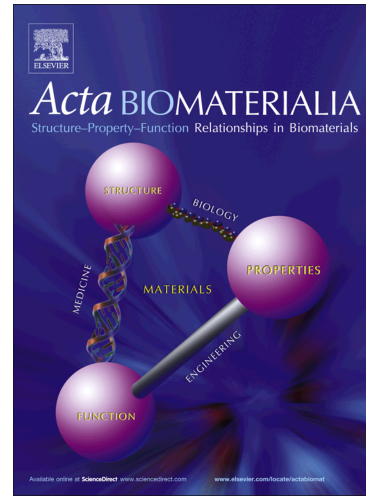

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Asymmetric Flexural Behavior from Bamboo's Functionally Graded Hierarchical Structure: Underlying Mechanisms

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Abstract

As one of the most renewable resources on Earth, bamboo has recently attracted increasing interest for its promising applications in sustainable structural purposes. Its superior mechanical properties arising from the unique functionally-graded (FG) hierarchical structure also make bamboo an excellent candidate for bio-mimicking purposes in advanced material design. However, despite its well-documented, impressive mechanical characteristics, the intriguing asymmetry in flexural behavior of bamboo, alongside its underlying mechanisms, has not yet been fully understood. Here, we used multi-scale mechanical characterizations assisted with advanced environmental scanning electron microscopy (ESEM) to investigate the asymmetric flexural responses of natural bamboo (*Phyllostachys edulis*) strips under different loading configurations, during "elastic bending" and "fracture failure" stages, with their respective deformation mechanisms at microstructural level. Results showed that the gradient distribution of the vascular bundles along the thickness direction is mainly responsible for the exhibited asymmetry, whereas the hierarchical fiber/parenchyma cellular structure plays a critical role in alternating the dominant factors for determining the distinctly different failure mechanisms. A numerical model has been likewise adopted to validate the effective flexural moduli of bamboo strips as a function of their FG parameters, while additional experiments on uniaxial loading of bamboo specimens were performed to assess the tension-compression asymmetry, for further