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Comparative Study of Jute, Coir and Bamboo Fibers Based on Uncertain Data

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Extended Abstract

Managing uncertainty or variability in material properties poses significant challenges when determining design parameters for product development, a difficulty further amplified when working with natural materials. Addressing this issue has long been a focus of research. In this study, the uncertainties in tensile strength, Young's modulus, and strain characteristics of natural fibers—specifically jute (J), coir (C), and bamboo (B) fibers—are systematically quantified. The authors introduce a method for quantifying these uncertainties using both probabilistic approaches (e.g., normal and Weibull distributions) and possibilistic approaches (e.g., fuzzy numbers). The results from the possibility distributions are compared with those obtained from probability analyses. A material selection framework is developed as shown in Fig. 1. This framework consists of five components. The first is the introduction of alternative materials (in this case natural fibers). The next component is the performing material characterization testing. The third component quantifies the uncertainty using the abovementioned methods. The fourth component is the creation of database using the induced probability and possibility distribution. This final component is the making the right decision.

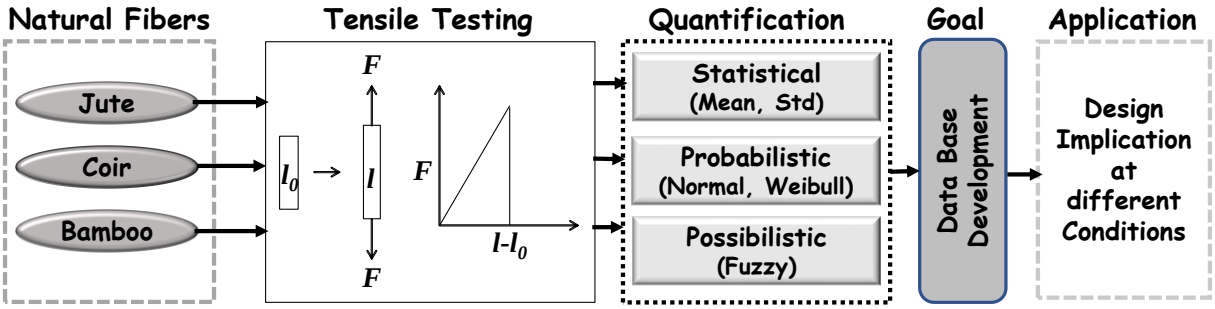

Figure 1: Schematic diagram of experimental procedure

It was found that the tensile strength (TS) of jute fiber varied significantly, ranging from 20 to 500 MPa, while its Young's modulus (E) varied from 2 to 100 GPa. Similarly, the tensile properties of coir fiber showed uncertainty, with TS ranging from 150 to 300 MPa and E from 2 to 6 GPa. Bamboo fibers exhibited even wider variability, with TS ranging from 400 to 1200 MPa and E from 21 to 50 GPa. This substantial variability has more effectively been quantified using possibility distributions rather than probability distributions. Four different scenarios were considered for material selection based on strength, modulus, and cost. Case 1 represents a strength-limited design, Case 2 indicates a stiffness-limited design, Case 3 focuses on a cost-limited design, and Case 4 considers all criteria as equally important, as shown in Table 1. The case studies reveal that when all criteria are equally important, or when the importance of modulus and strength is high, bamboo fibers are preferable to coir and jute fibers, with coir being a better option than jute. However, in the cost-limited scenario (Case 3), bamboo remains the top choice, but jute becomes a more favorable option than coir.

Table 1: Decision scores.

Alternatives	Case 1	Case 2	Case 3	Case 4
Jute	0.092833	0.088546	0.086025	0.506214
Coir	0.110041	0.089743	0.080334	0.539994
Bamboo	0.126432	0.134656	0.12674	0.549029
Ranking	**B > C > J**	**B > C > J**	**B > J > C**	**B > C >J**

This research presents a robust framework for selecting biobased materials in sustainable product development. Utilizing possibility distributions enhances the capacity to manage uncertainty in the properties of natural fibers, thereby facilitating more informed and reliable design decisions. Future research can delve into other natural materials, paving the way for the development of a comprehensive system for sustainable material selection.

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