INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

Name of the Student : **ABIR SAHA**

Roll Number : **196103002**

Programme of Study : **Ph.D.**

Thesis Title: **DESIGN AND DEVELOPMENT OF *BAMBUSA TULDA* REINFORCED BIOCOMPOSITES FOR STRUCTURAL APPLICATIONS**

Name of Thesis Supervisor(s) : **Dr. Poonam Kumari**

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SHORT ABSTRACT

Traditional materials like metals, ceramics, and polymers cannot provide the unique combination of qualities needed to match advancements in modern technologies, leading to a focus on composites. Due to environmental concerns and the disadvantages of synthetic fibers, research is increasingly focused on natural fibers to develop sustainable, biodegradable composites that are suitable for automotive, aerospace, and construction because of their excellent strength-to-weight ratio. Using bamboo-based biocomposites as an example of eco-friendly and sustainable material development, the present study focused on designing and developing eco-friendly and sustainable biomaterials. This study investigates the physical, mechanical, structural, and thermal properties of Bambusa tulda fiber and its reinforced green composites. Initial investigations were conducted on fibers extracted from the inner, middle, and outer parts of bamboo culms, evaluating their physical, chemical, mechanical, and thermal properties. Physical and tensile properties of the fibers were analyzed using Weibull's statistical approach. The investigation revealed that technical fibers extracted from the outer part (external technical fibers) of the bamboo culm had higher cellulose content (58.13 ± 3.51%), higher crystallinity index (60.142%), greater tensile strength (365.014 ± 50.441 MPa), modulus (14.098 ± 1.763 GPa), lower moisture absorption capacity, and higher thermal stability than fibers from the middle and inner parts of the bamboo. The extracted external technical fibers were then chemically treated with different concentrations of sodium hydroxide (NaOH). Various characterization processes were used to examine the effects of chemical treatment. Single-fiber tensile testing, fiber pull-out testing, X-ray diffraction (XRD), Fourier transform infrared spectroscopy (FTIR), thermogravimetric analysis (TGA), and atomic force microscopy were performed to examine the impact of these treatments. The investigation found that fibers treated with 6% NaOH exhibited a tensile strength of 526.452 ± 17.509 MPa and a tensile modulus of 24.055 GPa, both higher than those of untreated fibers. These treated fibers also had higher cellulose content and greater surface roughness, which improved interfacial interaction with the polymer matrix. Furthermore, green composite samples were fabricated with various fiber weight fractions (10%, 20%, 30%, and 40%). As compared to untreated fiber composites, 30% fiberloaded composites exhibited maximum tensile strength, tensile modulus, and flexural strength of 94.56 ± 5.56 MPa, 5.11 ± 0.266 GPa, and 97.8 ± 5.11 MPa, respectively. The effect of chemical treatments on the mechanical properties of biocomposites was investigated using composites with a 30% fiber weight fraction and different NaOH treatments. Composites with 30% fiber weight fraction, 6% NaOH treatment showed better tensile strength (132.916 MPa), tensile modulus (6.983 GPa), flexural strength (154.8 MPa), modulus (8.243 GPa), and impact strength (44.06 kJ/m²), with reduced moisture absorption compared to untreated fiber reinfored composites. Additionally, the effect of different polymer matrices on the thermo-mechanical and physical properties of the composites were analyzed. The best material among the developed composites was selected using a multi-criteria decision-making (MCDM) technique, VIKOR. Bamboo microparticles and bamboo fibers were hybridized to produce bamboo fiber-reinforced biocomposites to improve their properties, and their thermomechanical properties were analyzed. The developed hybrid composites showed a maximum tensile strength of 163.17 ± 6.44 MPa, a flexural strength of 144.26 ± 4.44 MPa, and an impact strength of 64.52±5.97 kJ/m². These values are higher than those for non-hybrid composites by 12.72%, 19.79%, and 12.07%, respectively. These findings highlight the potential of these developed composites for advanced structural engineering applications across various industries, including automotive, aerospace, packaging, electronics, sports, medical devices, and construction.