8 Statistical Review of Bamboo's Mechanical Properties for Building Applications

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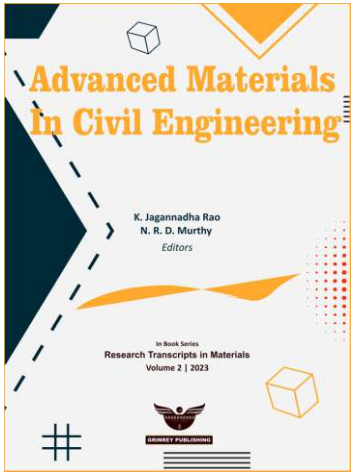

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Abstract

Materials which are high yielding and sustainable are now being researched to serve human demands because of rising global expansion and unfriendly utilization of raw

materials. Bamboo is a rapidly growing, long-lasting material that may be used to satisfy most human requirements (such as housing, nourishment, and equipment). With scientific discoveries, innovation and knowledge, humankind is revisiting several habits and reverting to some more traditional approaches and techniques that are beneficial to human wellbeing, ecological and overall sustainable development in the 21st century. This study primarily emphasizes how to utilize bamboo for technical purposes, driven by these ecological issues. To begin, a material should be damagingly evaluated to obtain physical property before it can be used in engineering and construction projects. As a result, a thorough review of the existing literature on bamboo mechanic property values was studied. It was discovered that combining physical properties of every property and linking the variation in property values with bamboo characteristics shows that bamboo is the most suitable green material.

1. Introduction

Bamboo is a naturally sustainable material applied as a project material for construction in some countries. Studying and quantifying the mechanical characteristics of bamboo is vital to create standards. Even though numerous studies have evaluated the mechanical properties of bamboo, the information is not being integrated mechanical characteristics were combined to produce mean values, and then studied by variable to understand which of these impact mechanical properties features [3]. In comparison to the overall usage of traditional construction materials such as Steel (56 percent), concrete (28 percent), and other forest resources (16 percent), bamboo accounts for less than 0.1 percent of all global building materials. Bamboo on the other hand, offers a lot of possibilities for application. To promote the usage of bamboo, there is a general dearth of knowledge, acceptance of material qualities and research outcomes [4]. If bamboo fails to sustain the buildings in such situations, it will be disastrous. This emphasizes the need of analyzing bamboo’s mechanical qualities. Furthermore, the mechanical qualities of bamboo vary depending on the species, and there are over 1,450 different bamboo species worldwide. As a result, it is critical to research and test various bamboo species to identify the mechanical qualities [5]. The following parameters were evaluated: strength, density, and moisture content. The goal of this work is to collect and statistically compare mechanical property data to determine means and variations and to correlate it to

characteristics mentioned in bamboo research as influencing mechanical parameter data.

2. Method

The strengths like ultimate, compressive, tensile and bend and elastic modulus of various parameters such as compressive, bending, and tensile were examined. Each study's average mechanical characteristics values were taken from several of the papers. The meanings and symbols for each characteristic are listed in Table 1 below.

Mechanical Qualities	Symbol	Units	Description
Ultimate Strength	F_v	MPa	When a specimen fails under shear, the strength is reduced
Compressive Strength	F_c	MPa	High compressive force divided by cross-sectional area at the preliminary
Bending Strength	F_b	MPa	At the point of bending failure, tensile strength is measured
Tensile Strength	F_t	MPa	Highest tensile stress at breaking, ultimate tensile strength
Compressive Elastic Modulus	E_c	GPa	Compressive force per unit area divided by change in length over initial length
Bending Elastic Modulus	E_b	GPa	Ratio of stress to strain flexural deformation
Tensile Elastic Modulus	E_t	GPa	Ratio of tensile stress to tensile strain
Modulus of Elasticity	E	GPa	Combination of values of compressive, bending, and tensile Modulus of Elasticity

3. Results and Discussion

3.1. Strength

According to the study conducted by authors such as Sooryalakshmi et. al [6], Ahamad et. al [7], Chand et. al [8] ,Awalluddin et. al [9] and Zhang

et.al [10] Fig.1. shows the compilation of data of mechanical test properties such as tensile strength, compressive strength, shear strength and bending strength. The bar reflects the median for each type of tests. Shear strength is 9MPa, compressive strength is 52 MPa, bending strength 120 MPa and tensile strength of 159 MPa. The presented median mechanical strength values for bamboo signify its balanced and promising mechanical performance for construction and engineering applications. These values suggest that bamboo possesses a harmonious combination of strengths, making it suitable for various load-bearing scenarios. However, it is important to acknowledge the inherent variability among bamboo species and their specific properties, emphasizing the need for detailed species-specific assessments to inform accurate design and utilization decisions.

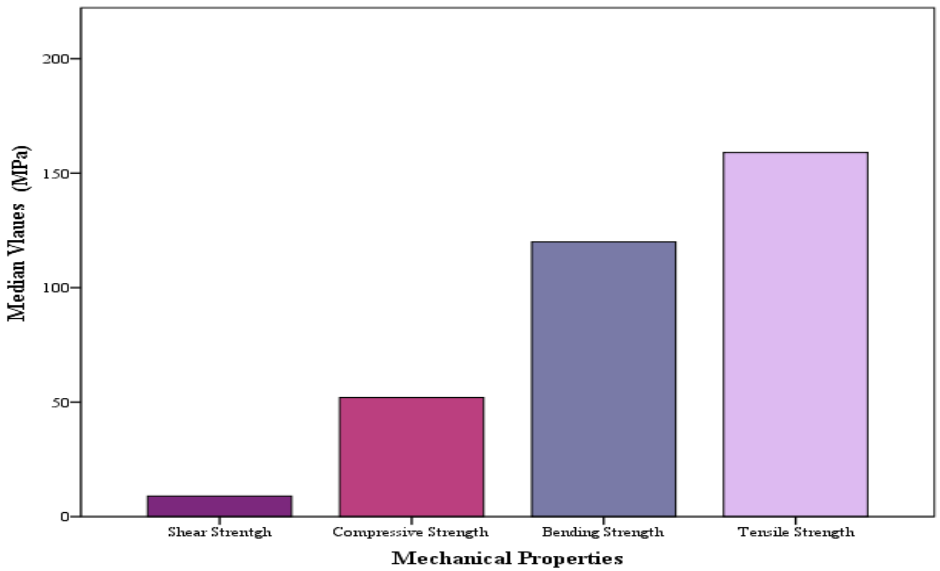

Fig. 1. Values of F_v, F_c, F_b

Fig.2. accentuates bamboo's substantial modulus of elasticity values, positioning it as a viable construction material. The median moduli of elasticity are recorded as 16 GPa for compression, 17 GPa for bending, and 14 GPa for tension. [3].

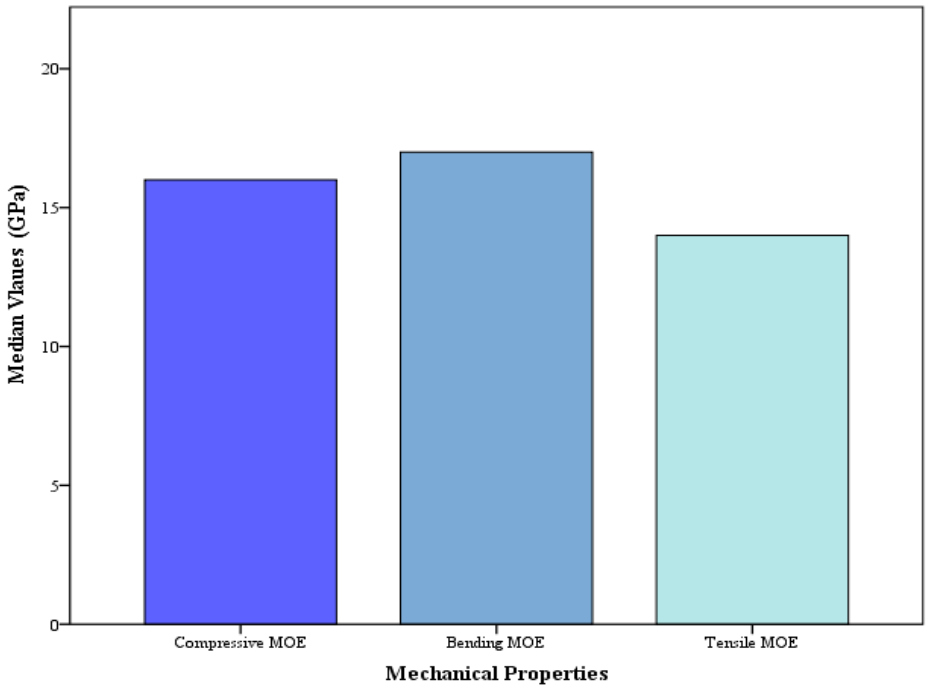

Fig. 2. Values of E_c, E_b, E_t

An experiment was carried out by Lakkad and Patel to investigate the overall mechanical characteristics of bamboo. As seen in Fig. 3. bamboo's specific modulus of elasticity is equivalent to unidirectional glass reinforced plastic but lesser than mild steel's specific MOE. The specific qualities provide information on comparative strength and stiffness on a mass basis, especially when subjected to unidirectional stresses [5].

3.2. Density

Sánchez Vivas claims that the density of bamboo has a significant impact on its mechanical qualities. However, there is no relation between density levels and mechanical qualities for ninety-one data sets shown. A moderate relationship is usually defined as a Pearson's r value of 0.27. In Fig. 4. strongest Pearson's values are indicated by greater coefficient of determination, but in this all wherever lower. There is a strong positive correlation between density, bending modulus of elasticity and bending strength values. According to study, the greatest coefficient of

determination is 0.114 which was for bending strength. The bending strength and bending modulus of elasticity readings may be determined based on a study by combining densities and the bamboo's outer diameter [3].

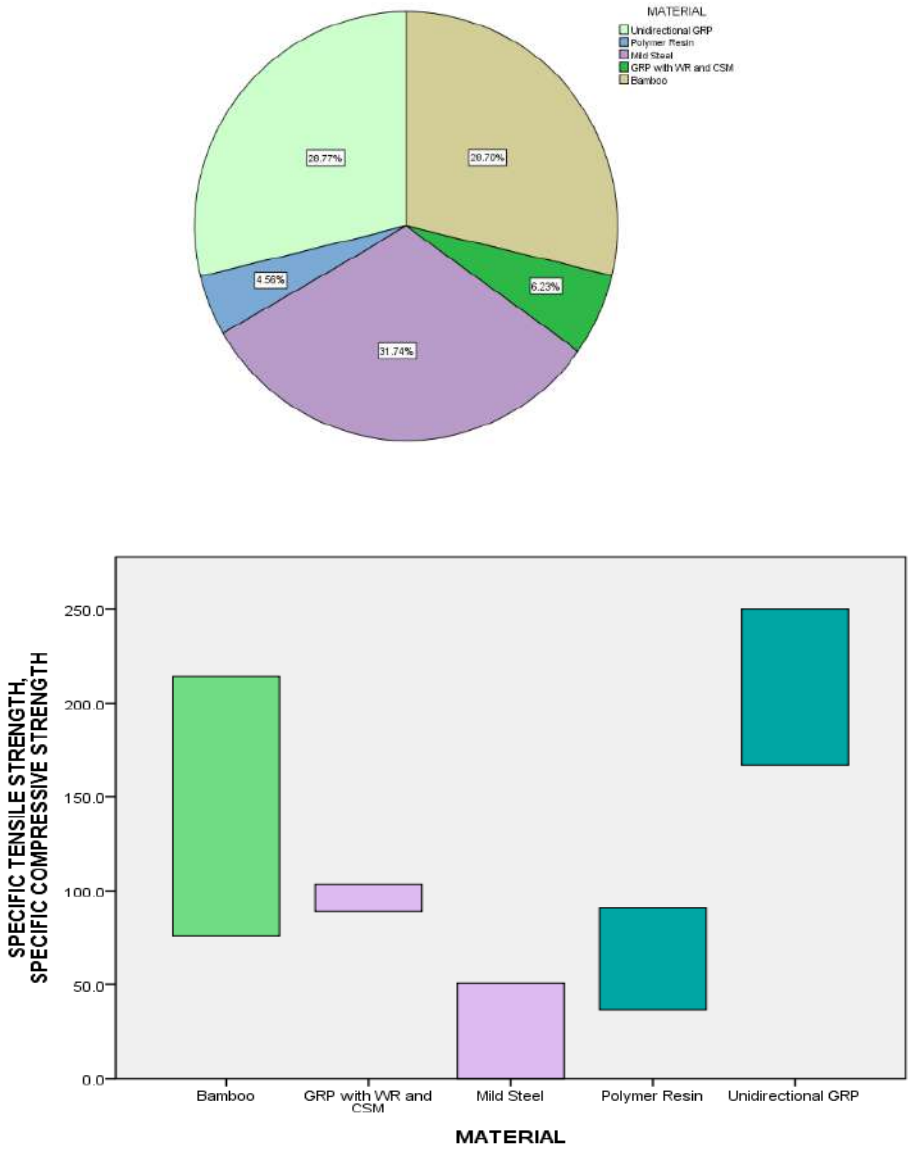

Fig. 3. Results of tensile and compressive tests

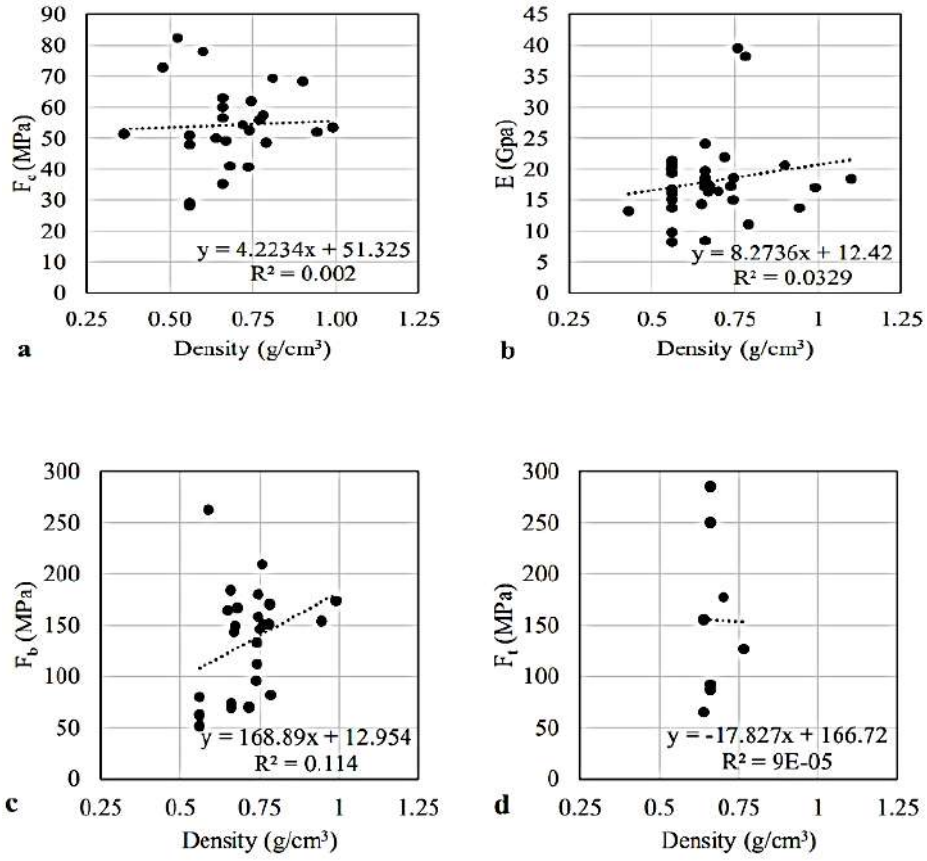

Fig. 4. Comparison between - (a) Density and F_c, (b) Density and F_b, (c) Density and E, (d) Density and F_t
Source: Sánchez Vivas, (2019) [3]

3.3. Moisture Content

In Fig. 5. cumulative moisture content against mechanical property shows that when separated into higher than or less than 15 % moisture content, a bi-model connection is observed for bending strength as well as to a lesser extent for compressive strength, modulus of elasticity and shear strength. The following has been the relation: First, qualities are entirely distinct for moisture content 15 % or less (highlighted in red); Second, properties show a rising, falling or constant correlation for moisture

content 15% or above. Since there were insufficient moisture content readings, tensile strength that they were not provided.

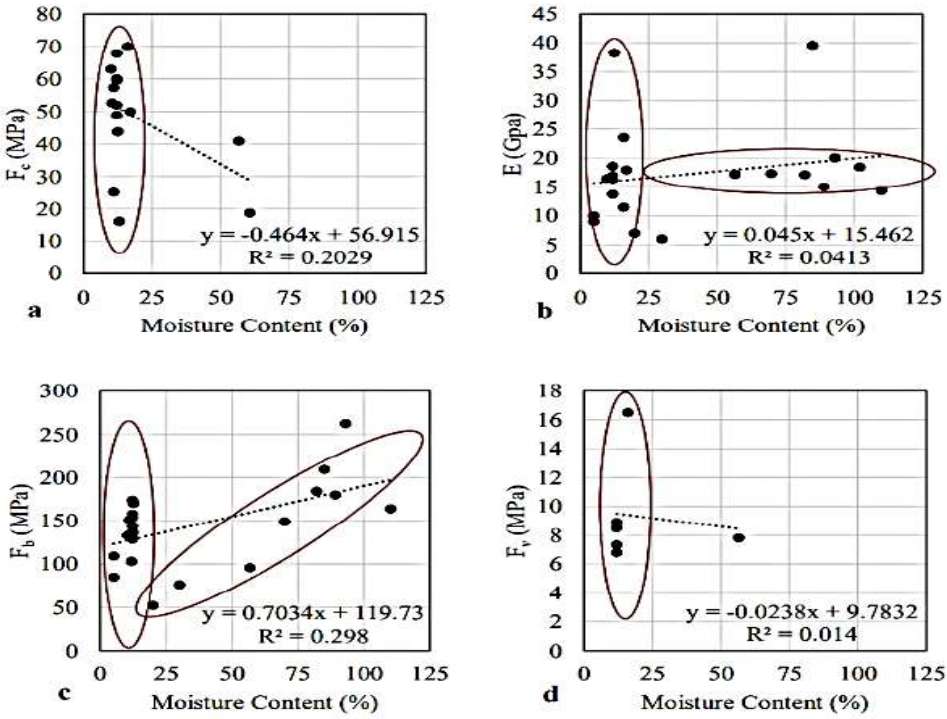

Fig. 5. Comparison of Moisture Content with (a) F_c (b) E (c) F_b (d) F_v
Source: Sánchez Vivas, (2019) [3]

To avoid fungal infection, the bamboo must be dried to such a moisture level significantly lower around 20 percent irrespective of its relationship among mechanical property and moisture content [3].

4. Conclusion

Several researches had sought to link bamboo's mechanical qualities to a variety of factors. The results justify adopting a fixed mechanical characteristic for all bamboo species and understanding variance in Table 2. The testing standards and moisture content were discovered to have an impact on bamboo's mechanical properties. We have presented

generalized mean values for key mechanical attributes, recognizing that these averages provide a foundational overview. However, we acknowledge the inherent variability among bamboo species, which may lead to deviations from these generalized means. Readers are encouraged to consider this variability and delve into the rich array of research to gain a holistic insight into bamboo's diverse mechanical characteristics.

Table 2. Mean value of Mechanical properties of bamboo

Mechanical Property	Mean Value
F_v	9 MPa
F_c	52 MPa
F_b	120 MPa
F_t	159 MPa
E_c	16 GPa
E_b	17 GPa
E_t	14 GPa
E	16 GPa

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