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Mechanical Properties of Concrete Incorporating Bamboo as Sand Replacement

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KEYWORDS

Thesis
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Bamboo
Concrete Mixture
Compression Strength
Permeability Testing
Splitting Testing
Flexural Testing

ABSTRACT

In this paper, to reduce the natural resource's uses such as sand in concrete replace by bamboo to avoid negative impact for environment. Then, the objective are to analyze the strength characteristics of bamboo, to evaluates the mechanical and physical of properties of concrete mixture with bamboo and to investigate the relationship between mechanical and physical of concrete mixture with bamboo need to be achieve. To achieve these objectives, bamboo was processed into shape similar with size of sand < 4.5mm and mixed into concrete at various replacement ratios (0%, 1%, 2%, 3%, and 5%). Standard concrete tests such as compressive strength, flexural strength, permeability test and splitting testing were conducted according to ASTM standards. The physical properties such as density and water absorption were also measured to determine the relationship between mechanical and physical properties. From the experimental works (major findings) were understood. From these results, it can be conclude that (conclusion).

1. INTRODUCTION

Malaysia's construction sector has seen significant growth driven by large-scale infrastructure, residential, commercial, and industrial projects where ready-mixed concrete serves as a critical structural and performance material. Malaysia has undergone rapid development, particularly in the construction sector, which has played a key role in supporting the country's economic stability. Concrete is a composite material made up of cement, fine aggregate (sand), coarse aggregate (gravel), water, and admixtures. Cement and mineral ingredients are combined to create concrete, a solid composite material. Because of its many strength classes and excellent properties, concrete has been employed extensively in civil engineering resilience [1]. To produce concrete of acceptable quality in an economical and efficient manner, it is essential to determine the correct proportions of these ingredients. Concrete, being a quasi-brittle material, fails differently under compression, tension, shear, or flexure due to its heterogeneous composition of cement paste, aggregates, and voids [2]. Based on previous research findings, several papers have explored replacing sand in concrete with various alternative materials to achieve results comparable to traditional method. Nonetheless, with the current traditional mix design methods, when concrete is made by partially or fully substituting natural aggregate with recycled aggregate, the total unit mortar in the concrete increases and the share of original coarse aggregate diminishes because of the adhered mortar present in the recycled aggregate [3]. For example, bamboo fiber was substituted for aggregate in order to save building material costs and pollution while simultaneously enhancing concrete quality. Finding the ideal amount of bamboo fiber to substitute aggregate in concrete and comparing the compressive strength of bamboo fiber concrete to regular concrete are the goals of this study [4].

2. EXPERIMENTAL PROCEDURE

2.1 For Material Preparation

Cement, fine aggregate (sand), coarse aggregate, water, and bamboo were used in this study. The bamboo used was Dendrocalamus asper, which was cleaned, dried, and cut into small with range <4.5mm.

2.2 Mix Design

The concrete mix was prepared with a fixed water-cement ratio of 0.5. Bamboo were added in varying proportions of 0%, 1%, 2%, 3%, and 5% by weight of cement. All materials were mixed thoroughly in a concrete mixer until a uniform consistency was achieved. Fresh concrete was poured into standard cube moulds (100 mm × 100 mm × 100 mm) for compressive strength testing and beam

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moulds (100 mm × 100 mm × 500 mm) for flexural strength testing using cylinder moulds (100 mm x 200 mm) based on table 1.1. The concrete was compacted using a vibrating table to remove entrapped air.

2.3 Casting

After 24 hours of casting, the specimens were removed from the moulds and cured in clean water at room temperature (27 ± 2°C) for 7, 14, and 28 days.

2.4 Curing

After curing, the specimens were tested for mechanical and physical properties. The compressive strength test was performed using a universal testing machine (UTM) according to ASTM C39, while the flexural strength test followed ASTM C78.The splitting strength test according to ASTM C496/C496M and permeability follow BS EN 12390-8.

Table 1 Sample of Preparation

No.	Test	Size (mm)	Mould	No. of Sample
1	Compression Permeability	100 mm x 100 mm x 100 mm	Cube	80
2	Splitting Test	100 mm (dia.) x 200 mm (H)	Cylinder	20
3	Flexural Test	100 mm x 100 mm x 500 mm (L)	Prisme	20
			Total	**120**

3. RESULTS AND DISCUSSION

Before presenting the results, the tensile and compressive strength tests were conducted to determine the mechanical properties of the bamboo samples. These tests aimed to evaluate the ability of bamboo to resist tension and compression forces, which are important parameters in assessing its suitability as a construction material.

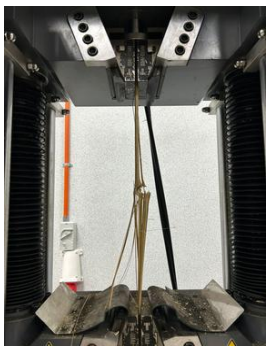

Table 2 Data of Tensile Strength

MATERIAL	BATCH	TENSILE (Mpa)
BAMBOO	1	238
	2	214
	3	118

The tensile strength of bamboo was recorded at 238 MPa, indicating that bamboo possesses excellent tensile capacity comparable to mild steel in certain conditions. This high tensile strength demonstrates bamboo's potential as an effective reinforcement material in concrete structures, particularly in tension-bearing applications. The strong tensile performance can be attributed to the longitudinal alignment of bamboo fibers, which enhances its ability to resist pulling forces.

Table 3 Data of Compressive Strength

BAMBOO	DATE	COMPRESSION STRENGTH (Mpa)
1	29-Sep	11.934
2		11.235

In contrast, the compressive strength of bamboo was measured at 12 MPa, which is significantly lower than its tensile strength. This is typical for natural fibrous materials, as the hollow and fibrous internal structure of bamboo is less effective in with standing compressive loads. Nevertheless, the compressive strength value obtained is still sufficient to support its role as a sustainable alternative material in non-structural or partially reinforced concrete components.

Overall, the results confirm that bamboo exhibits high tensile-to-compressive strength ratio, making it more suitable for tension applications rather than compression. This property highlights bamboo's potential to replace or supplement steel in lightweight and eco-friendly concrete systems.

4. CONCLUSION

The mechanical performance of concrete mixtures incorporating bamboo as a partial replacement for fine aggregate shows promising potential. Although a slight reduction in compressive strength was observed compared to conventional concrete, the tensile and elasticity properties of the bamboo mixture remain significant and demonstrate good potential for practical applications.

The measured tensile and compressive strengths of bamboo itself (238 MPa and 12 MPa, respectively) indicate that bamboo possesses desirable mechanical properties. These results highlight bamboo's capability not only as a reinforcing material but also as a sustainable alternative for partial sand replacement in concrete.

This study has addressed the research gap regarding the use of bamboo as a sand replacement in concrete, particularly in terms of its mechanical, physical, and permeability characteristics. From an environmental perspective, the utilization of bamboo an abundant, renewable, and biodegradable material can reduce dependency on natural sand resources. This approach supports the principles of green construction and promotes environmental conservation.

Future research is recommended to explore the durability performance of bamboo concrete under various environmental conditions, such as chemical exposure, water absorption, temperature variation, and load repetition. In addition, studies on optimizing bamboo content, surface treatment, and admixture integration should be conducted to enhance overall performance.

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