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Study on The Properties of Bamboo Fibre-Containing Concrete Due to Strength

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Abstract: Concrete constructions are durable. Substandard environmental conditions contribute to concrete building cracks, reducing their durability. Despite its widespread usage in construction, concrete has limited strength, poor impact strength, and cracking. As concrete's strength increases, its ductility is thought to decrease, however the opposite is the case in several structural applications. This study was conducted to investigate the workability of concrete in order to increase its strength rate. Apart from that, the objective of this study is to ascertain the mechanical and physical properties of bamboo fibre when mixed with Portland cement. This study analysed the structural value of bamboo fibre in a blended Portland cement, taking into consideration its appropriateness for concrete. Bamboo fibres at 0.10 %, 0.20 %, and 0.30 % were utilised as an additive in 1:0.75:1.5 concrete mixes. The concrete grade employed was M30. The workability of the mix was assessed by slump; the cement was subjected to a conventional consistency test. This demonstrates that the workability of normal concrete is medium, that the slump value is 68.58mm, and that the actual slump is a form of slump. Compressive strength was determined at 7, 14, and 28days for hardened cured (150 x 150 x 150) mm concrete cubes and the result for 0.10 % sample is 26.37MPa, which is a little drop from the strength of the control sample, which is 33.83 MPa. Additionally, the rate at which bamboo fibre concrete absorbed water climbed steadily between 0.10 %, 0.20 % and 0.30 %. Following this, thermal conductivity testing, which is important in determining the level of heat transfer in concrete through conduction, which may lead to cracking and show that 0.2% of additive bamboo fibre in concrete have the density 2009.46 kg/m3 and the thermal conductivity is 0.177(W/m°C).

Keywords: Concrete, Bamboo Fibre, Slump Test, Compressive Test

1. Introduction

Throughout the previous century, significant infrastructure has been constructed. Concrete structures, in instance, were a significant portion of the structures. Some of these concrete buildings are almost 40 years old, and their maintenance is a critical aspect of civil engineering. Durability is a

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requirement for concrete buildings. In essence, the consequences of substandard environmental conditions cause cracks in concrete structures, reducing their durability. Despite its widespread usage in construction, concrete poses significant risks, including weak strength properties, impact resistance, and cracking. It is usually considered that as concrete's strength increases, its ductility decreases, and so the discovered inverse connection between strength and ductility is properly considered in a few structural applications. A study conducted to overcome the problem of workability of concrete to increase the rate of strength.

Concrete is described as a material composed of embedded filler in a rigid matrix concrete material that has been bonded between aggregate particles. It is necessary for the bonding of implanted concrete particles or pieces of coarse aggregates. Concrete is manufactured in a variety of ways, including batching, mixing, consolidating, finishing, and curing. Concrete is one of the most often utilized materials. It is made of three primary components: fillers, sand, and cement, which acts as a bonding agent and makes concrete. Compressive strength is high, while tensile strength is poor. They are reinforced with fibers to compensate for their low tensile strength. Due to the great energy absorption rate of concrete fiber during collisions, it is not readily broken apart. Adding fiber to concrete to enhance its qualities began in the early 1960s. Over the last six decades, significant advancements have been made in the addition of fiber to concrete to achieve different desirable proportions. [1]

The species of bamboo used in this study is Semantan Bamboo, which can be identified from other species by the diameter of its culms (culm diameter). Generally, Semantan Bamboo has a wide diameter of culms. It is found up to about 1200m in elevation and often spreads into disturbed habitats, from lowland to hilly areas, along streams and rivers, and in valleys. Based on past study, parallel to the grain, Semantan Bamboo has a high compressive strength. [2] Elasticity and stress elastic modulus at the proportional limit with respect to the skin at the internode section. The bamboo has been utilized for the construction of structure elements such as supports, columns, roofs, etc.

1.1 Problem statement

Plain concrete has a very low compressive strength, minimal ductility, and little crack resistance. Structural cracks (micro cracks) develop even before charge in plain concrete and comparable fragile materials, especially as a result of drying shrinkage or other reasons for the volume change. Additionally, it is well established that temperature variations may result in stresses in concrete structures that are primarily of the same order of magnitude as the dead and live loads in some circumstances. As a result, using bamboo fibre as an addition in concrete can help to overcome all of these sorts of issues while also increasing the strength of the concrete.

1.2 Aim

This study aims to assess the evaluation effect of bamboo fiber on concrete. The following relevant objectives are outlined as follows in order to achieve the above goal and purpose:

1. To identify the properties of bamboo fiber
2. To analyze the effect of bamboo fiber as containing concrete due to compressive strength, thermal conductivity, and water absorption.
3. To propose the ideal concrete mixing ratio for achieving a strength almost equivalent to a normal concrete mix.

2. Materials and Methods

There was appropriate methodology process in direction of achieving the objectives of this study. In order to achieve this study, several procedures to conduct the study have been selected as shown in the overview of methodology process in Figure 1.

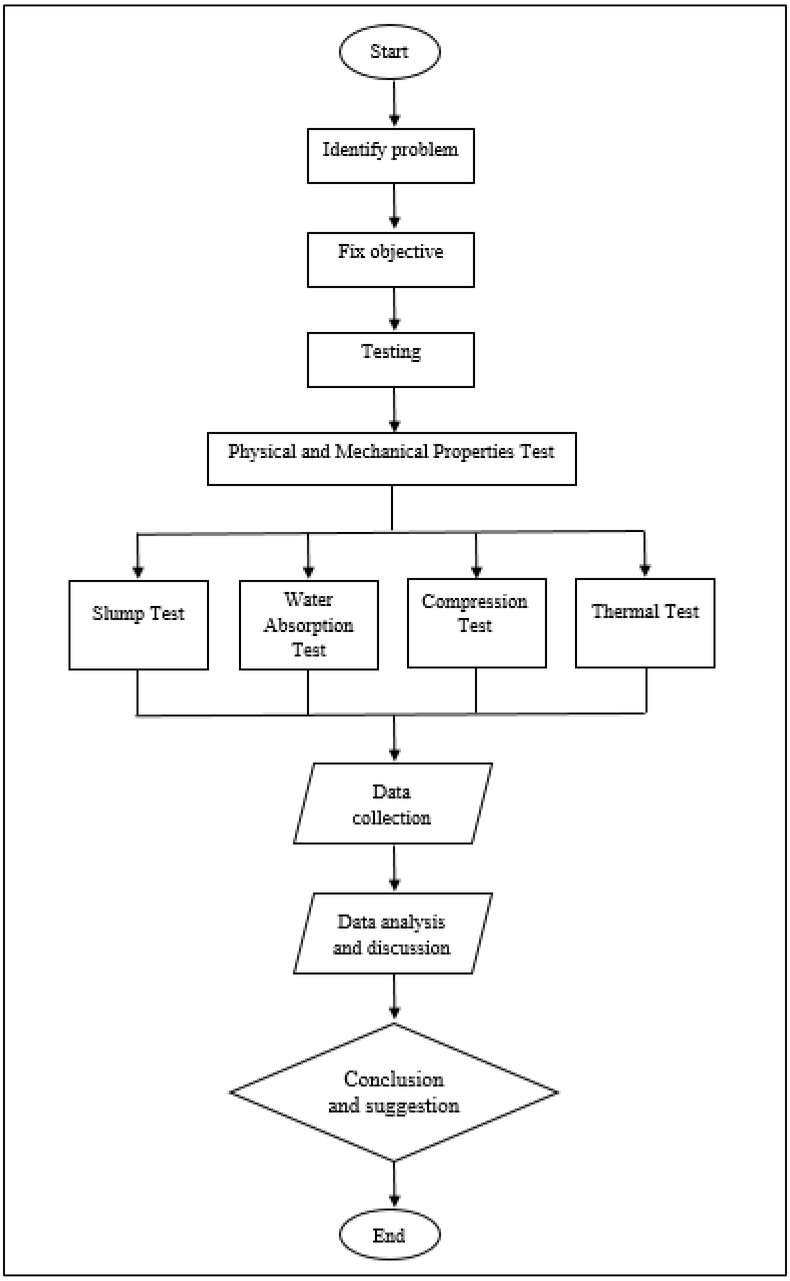

Figure 1: Flow Chart of Entire Project

2.1Materials

To successfully complete the research plan, the preparation of the materials is absolutely necessary. The following components of the process of designing new mix concrete using bamboo fibre as containing in concrete are created from the following materials.

2.1.1 Bamboo Fibre

The concrete mix includes bamboo fibres as an additional contained material. In this research, the percentage of bamboo fibre that was utilised ranged from 0 (for the purpose of serving as a control sample), 0.10 %, 0.20 %, and 0.30 %. The bamboo fibre was obtained from a supplier of bamboo in Kedah and, prior to combining, it is required to go through a number of procedures

2.1.2 Ordinary Portland Cement

Ordinary Portland Cement (OPC) was utilised in the formulation of this investigation's concrete mixture. The cement has to comply with the requirements of MS 522 Part 1: 1997. To avoid the quality of the cement from deteriorating, which would result in a reduction in the strength of the concrete, it is essential that the cement be made in a room that is sealed up.

2.1.3 Sand

Different sizes of fine sand were separated through sieving. In order to develop new mix concrete using bamboo fibre as a part in the concrete, only sand sizes passing 5mm sieves were employed in the production process.

2.1.4 Aggregate

The specific gravity and size distribution of aggregate were measured in accordance with ASTM C 127-88 and C 136, respectively.

2.1.5 Water

The water that is used in the mixing of the concrete is obtained straight from the tap. It is important that the water be spotless and clear of any outside elements.

2.2 Methods

In order to obtained data, 4 tests have been performed including slump test, thermal conductivity, water absorption and compressive test as mentioned in the passage below

2.2.1 Slump Test

The slump is defined as the height discrepancy between the mold and the height point of the specimen being tested. This procedure is repeated three times to obtain the most accurate reading of the spread diameter. ASTM C1611/C1611M-21 is used to conduct the test. Figure 2 show slump testing process.

Figure 2: Slump testing process

2.2.2 Thermal Conductivity

Heat transfer through concrete is measured using thermal conductivity, which is an important attribute in the construction industry since it determines how much heat is transferred through a concrete. [3] The thermal conductivity of the samples is measured in this investigation using the guarded hot plate technique as shown in Figure 3.

Figure 3: Guarded hot plate technique

2.2.3 Water Absorption

Water absorption testing is a common method for assessing concrete waterproofing. As in Figure 4, the dry weight of each cube in the curing tank is expected for water absorption after molding the 150 x 150 x 150 mm cubes.

Figure 4: Water Absorption Test

2.2.4 Compressive Test

The compressive strength of a concrete mixture is a widely regarded indicator of its overall performance. It is important to take into account this aspect of concrete since it is the main determinant of how well concrete can bear loads that have an impact on its overall size and shape. Using the Universal Testing Machine (UTM) shown in Figure 5.

Figure 5: Universal Testing Machine (UTM)

2.3 Detail of Sample

The compressive strength of hardened concrete will be tested in this study after 7, 14, and 28 days of concrete maturation. Meanwhile, thermal conductivity will be measured only after 28 days of concrete maturity. Water absorption will be determined on the same sample prior to compression testing. The sample quantity in detail is shown in Table 1.

Table 1: The detail number of samples

Testing	Sample	Fibre content %	Number of samples 7 days	Number of samples 14 days	Number of samples 28 days
Compressive strength test	Control	0	3	3	3
	Sample A	1	3	3	3
	Sample B	2	3	3	3
	Sample C	3	3	3	3
Water absorption test	Control	0	3	3	3
	Sample A	1	3	3	3
	Sample B	2	3	3	3
	Sample C	3	3	3	3
Thermal conductivity test	Control	0	0	0	3
	Sample A	1	0	0	3
	Sample B	2	0	0	3
	Sample C	3	0	0	3

2.3 Equation

In this study, there are several calculations, among which are involved are thermal conductivity, water absorption and compressive test.

2.3.1 Thermal Conductivity

Many devices have been created that make use of the guarded hot plate approach to directly evaluate the thermal characteristics of a range of materials, specifically the k-factor, in a safe and controlled environment. The steady state temperatures, specimen thickness, and heat input to the hot plate are all taken into consideration for determining thermal conductivity, which is done using the Fourier linear heat flow in following equation.

$$\lambda = \left(\frac{W}{A}\right) \cdot \left(\frac{d^1}{dT^1}\right) \; Eq.\ 1$$

Where:

λ = Thermal conductivity of the test specimen

W = Electric power input to the centre heater

A = Main heater surface area

d_1 = Specimen 1 thickness

dT_1 = Temperature gradient from hot plate to cold plate 1

2.3.1 Water Absorption

Water absorption refers to the percentage increase in weight comparison to the initial weight (in percent). Formula below illustrates how water absorption is calculated.

$$\text{Water absorption (\%)} = \left[\frac{(A-B)}{B}\right] \times 100 \quad Eq.2$$

Where:
A = Wet weight for concrete cube
B = Dry weight for concrete cube

2.3.2 Compressive Test

The compressive strength on the upward surface of that same concrete cube is apply. The calculation base on the following equation.

$$F = \frac{P}{A} \quad Eq.3$$

Where:
F = Force, (MPa)
P = Pressure on the load, (KPa)
A = Cross sectional area, (mm^2)

3. Result and Discussion

In order to validate the hypotheses and achieve the objective of the study, it is necessary to examine the data that was collected. This chapter goes through the data analysis, the results summary, and the interpretation of the research findings from the slump test, compressive strength, the thermal conductivity, and the water absorption.

3.1 Slump Test

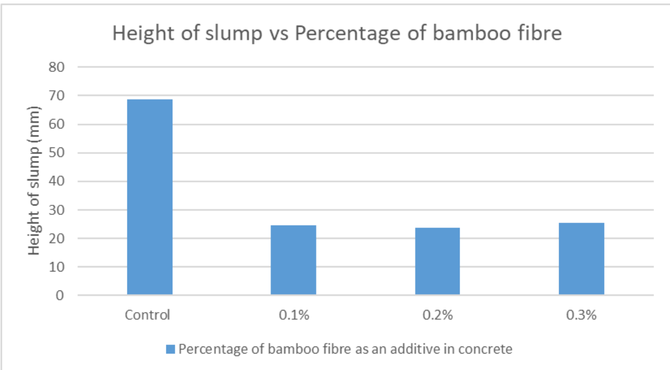

Figure 6: Slump test result

The results of the slump test for the control concrete and the bamboo fibre concrete are shown in Figure 6. This demonstrates that the workability of normal concrete is medium, that the slump value is 68.58 mm, and that the actual slump is a form of slump. The slump value of the bamboo fibre concrete mixture is 24.5 mm for 0.10 % as an addition in concrete, 23.8 mm for 0.20 %, and 25.4 mm for 0.30 %. This value increases as the percentage of bamboo fibre increases. Zero slump of any kind was formed by any of the three different compositions of bamboo fibre concrete, and the workability was very low. The purpose of this evaluation was to examine the workability of concrete made from bamboo fibre as an addition in concrete. It was discovered that the degree of workability decreased in proportion to the percentage of bamboo fibre that was present in the concrete.

3.2 Thermal Conductivity

Table 2: Thermal conductivity data

Percentage of Bamboo fibre %	Density kg/m^3	Thermal resistance, R_{th} (°C/W)	Heat transfer rate, q (W)	Thermal conductivity, k ($\frac{W}{m}$°C)
0	2316.78	3.09	11.97	0.168
0.1	1867.61	2.49	10.26	0.210
0.2	2009.46	2.94	8.64	0.177
0.3	2458.63	2.33	11.07	0.224

Thermal conductivity was tested by Thermal Conductivity of Building Materials Apparatus (Model: HE110). From Table 2, thermal conductivity varies according to density. When the density is 2316.78 kg/m3, the thermal conductivity is 0.168 (W/m°C) for control sample which is zero additive of bamboo fibre. Then, for 0.1% of bamboo fibre, when the density is 1867.61 kg/m^3, the thermal conductivity is 0.210 (W/m°C). For 0.2% of additive bamboo fibre in concrete, the density is 2009.46 kg/m^3, the thermal conductivity is 0.177(W/m°C). Lastly for 0.3%, the density is 2458.63kg/m^3, the thermal conductivity is 0.224(W/m°C). The amount of air that is contained in concrete mixes has an effect on its thermal conductivity. The effect of heat transfer caused by convection through the air in the sample will be reduced in proportion to the sample's smaller air space sizes.

3.3 Water Absorption

The average water absorption values of bamboo fibre concrete are displayed in Figure 7. The results of the water absorption test conducted on bamboo fibre concrete reveal that the line persist increased as the proportion of bamboo fibre added to the mixture increased. The rate at which bamboo fibre concrete absorbed water climbed steadily between 0.10%, 0.20 % and 0.30 %. This increase in absorption rate is attributed to the porous surface and water-absorbing properties of bamboo fibre, which contribute to bamboo's overall composition. As a result, an increase in bamboo fibre is able to link empty spaces that are already present in the matrix and are capable of absorbing water. The upshot of this is that the cube mixture takes up less space in the mould the more tightly it is packed in there. When there is less available space, there is a slower rate of water absorption.

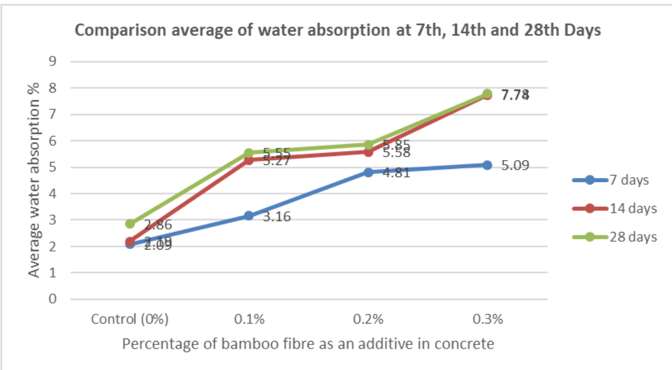

Figure 7: Average of water absorption

3.4 Compressive Test

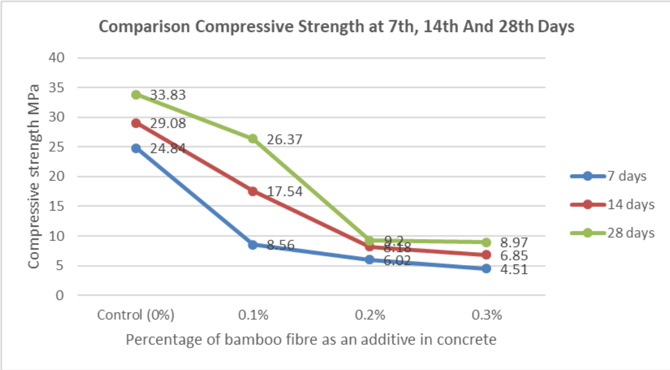

Figure 8: Comparison average compressive strength at 7, 14 and 28 days

This test was performed to meet the study's purpose. The concrete mixture was prepared for 30 MPa grade concrete. An average of three test results for each concrete batch have been collected. In this research, control mix was made. The control mix does not contain bamboo fibre. The study focused on the effect of concrete containing addition of bamboo fibre. Subsequently, the control mix was utilised as the major comparison of concrete containing fibre to evaluate the influence of bamboo fibre on concrete strength. Figure 8 is a graph that compares the average compressive strength after 7, 14, and 28 days. The graph demonstrates that the sample consisting of 0 percent has a value that is superior to that of the other sample. The present ratio of bamboo fibre results in a reduction in compressive strength, but the ideal ratio of bamboo fibre to concrete is 0% and produces a better level of compressive strength as a direct consequence. On the other hand, the compressive strength of concrete can be made weaker by along with a high porosity in the concrete that has been mixed. Aside from that, the reduction in strength is typically caused by a lack of adhesion between the bamboo fibre and the concrete mix. During the loading process, cracks will quickly form around the bamboo particles, which will ultimately result in fast rupture on the concrete.

4. Conclusion

Based on the study that have been done, a few conclusions can be conclude based on the objectives outlined in Chapter 1. The first objective of this study is to identify the properties of bamboo fibre. This objective was achieved when in the literature review in Chapter 2 mention the previous study.

As a result of a variety of laboratory tests and experimental works, aim number two has been accomplished, which is to study the effect of bamboo fibre as containing concrete related to compressive strength, thermal conductivity, and water absorption. The workability of fresh concrete was found to decrease with an increase in the fibre content and also a decrease in the workability with the increase in the aspect ratio. Besides that, the addition of bamboo fibres at 0.1% by volume causes a significant enhancement in early as well as long term compressive strength of concrete. According to the findings of the research conducted, the water-absorption capabilities of bamboo improve with diminishing fibre size. When bamboo fibre has been added into concrete, it has the ability to lower the quantity of free water in the concrete by absorbing moisture from the concrete itself. To ensure that the material can be worked during the process of construction, we need to either control the amount of bamboo fibre that is existent or the amount of free water that is present in the concrete mix. Either way, this will ensure that the concrete mix can be worked effectively during the construction process. It is possible to get the conclusion that adding more bamboo fibre to concrete will not definitely result in an increase in the material's strength. The strength of the concrete made of bamboo fibre decreased as the amount of bamboo fibre used in the mixture was increased. On the one hand, there are a lot of spaces between the bamboo fibre content, and this will cause the concrete's strength to drop. In contrast, bamboo fibre is a type of natural plant fibre. On the surface of the bamboo fibre, there are a lot of organic components, which can prevent it from bonding more effectively with the concrete mix. This issue is also deeply connected to the heat conductivity of the material. The amount of air that is present in concrete mixes has an effect on its thermal conductivity. The effect of heat transfer caused by convection via the air in the sample will be reduced in proportion to the sample's smaller air space sizes.

In order to achieve a strength that is almost identical to a normal concrete mix, the third goal of this research was to identify the optimal concrete mixing ratio. According to the results, the optimum concrete mix contains 0.10 % bamboo fibre as containing concrete is the best even though the data results it does not reach a satisfactory level but it is close to a standard concrete mix. Although it cannot achieve the desired strength it can also be used for non -load bearing parts of the building.

Acknowledgement

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