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Bamboo Fiber as Enhancement Material in Concrete

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Abstract: Bamboo is one of Malaysia's most frequently practiced agriculture plant that can get easily. Bamboo grows in both tropical and subtropical climates. Due to their economical cost, now bamboo is usually being used as structural system. The objective of the study is an important aspect that need to be focus on. This is because it is the objective that determines the direction of the study. To formulate and determine the workability of the reinforcement concrete mixture of adding the bamboo fiber and determine compressive strength and tensile characteristics bamboo fiber in reinforcement concrete. This study focuses on the identification of using bamboo fiber in the concrete and it will be tested following the standard test of concrete that testing to determine the properties of the concrete after mixing it with bamboo fiber. The ratio of the bamboo fiber that being use in reinforcement concrete is determine by specific range, for the length of fiber is 30mm and the quantity being used in the ratio of concrete is 0%, 0.1%, 0.2%, and 0.3%. The concrete sample need for this test is 36 sample that is 24 cube sample size and 12-cylinder sample size. It can be concluded that bamboo is a sustainable plant-based material that can help in revolutionaries the construction industries to the next level of construction that can be more considerable as green construction

Keywords: Reinforcement Concrete, Bamboo Fiber, Sustainable Construction

1. Introduction

Based the research, bamboo fiber has a lot good properties that can be used in construction industry such as boost the value of concrete fractures by adding it to concrete mixes [1]. Carbon fiber derived from mineral rocks was commonly utilized in general. Due to their lack of stiffness and strength, natural plant fibers such as bamboo fiber were excluded. Natural plant fibers have environmental advantages because they are a product that get plant planting repeatedly and do not need high resource. The fibers introduced into the concrete have a substantial influence on limiting the formation of tensile cracks in concrete after it has cracked

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The concrete structure has a very low tensile strength, poor flexibility, and little crack resistance. Structural cracks appear in concrete and similar material properties even before they are loaded, due to drying shrinkage or other volume changes. As a result, alternative methods like as adding fiber to reinforced concrete have been used to solve all of these concerns [2]. The efficient of the adding, which is highly dependent on the type of fiber, fiber geometry, fiber content, orientation, and distribution of the fiber, mixing, and compaction, would definitely determine its properties.

Concrete is a composite material made by mixing the binding element cement or lime with the aggregates sand, gravel, stone, brick chips, water, admixtures, and other ingredients in particular amounts. The mixing proportions determine the strength and quality of the product. Concrete in a certain opinion is a product or mass made by the use of cementing medium [3].

Studies conducted based on these bamboo fiber reinforcement concrete can be more beneficial to construction industry application. Through this study conducted, there are several interests gained or achieved, several of it is increase the awareness of applying bamboo fiber in construction industry, to minimize the increasing of bamboo waste in ecosystem and lastly, increasing the concrete properties.

To overcome its weakness in tension, conventional steel bar reinforcement is utilized with fibers as a component material [4] There is a growing interest on the use of various natural fibers in structural application due to their light weight, low cost and sustainability. Natural fibers are cheap and have better stiffness per weight which results in lighter components [5]. Bamboo fiber will be utilized as an enhancing material in this study to reduce bamboo pollution while also improving the concrete quality.

2. Materials and Methods

The method is often explained in terms of a chart, followed by a detailed explanation of the subtopic, including the test that was performed. The major goal is to observed bamboo fiber mix ratio react in reinforcement concrete, followed by determining the workability, compressive strength, and tensile properties of bamboo fiber in reinforcement concrete.

2.1 Method

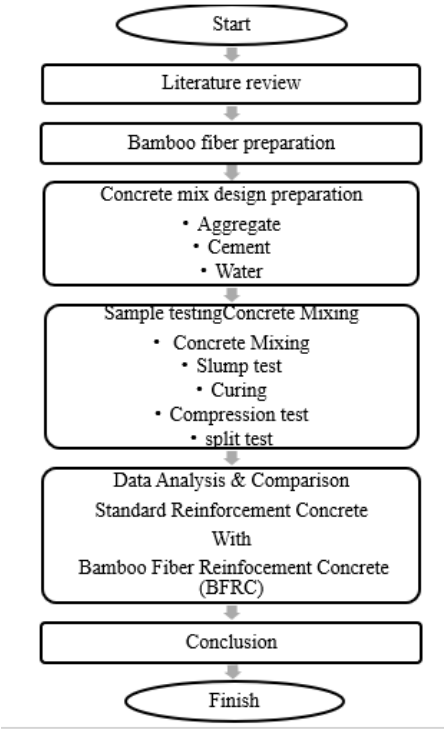


Figure 1 BFRC Production Flowchart

2.2 Material

To achieve the objective that being determined, the material that is bamboo fiber acting as additive material have been prepared with various length and quantity. This additive material will be added into reinforcement concrete to make sure; the main objective fulfils. The table 1 shown the raw material needed for this research.

Table 1 Raw material for concrete mixing

Material	Function	Figure
Cement	As a binder for the concrete	
Aggregate	Helping concrete mix more compact	
Water	To active chemical reaction call hydration with cement	
Bamboo fiber	Act as additive in reinforcement concrete	

Therefore, the material for concrete mix is not hard to create and handle, the material for the mix design is easy to collect and the material is not hard to be handle by a person.

2.2.1 Bamboo fiber

Bamboo consists of unidirectional fibers that are reinforced by parenchymatous ground tissue that functions as a matrix, the nonuniform distribution of vascular tissue along the radius direction indicates the feature of functionally graded materials for bamboo [6]. Bamboo fibers is a main material that needed in this research, it being choose as adding material in reinforcement concrete as its special characteristic above other natural fibers. [7].

Bamboo has more than 10 cellular layers in its cell structure, with each dissimilar microfibril orientation with thick layers and thin layers in alternate arrangement on the cell wall of bamboo fibers, the main chemical compositions of bamboo include cellulose, hemicellulose, and lignin, all kinds of extractions, a little ash, and silicon dioxide, these structures and characteristics contribute to bamboo's superior strength, toughness, bending ductility, and low density. [8]. The type of bamboo that being used in the research is bamboo heterostachya, bamboo heterostachya or locally called as buluh galah. The bamboo species can be found in locally at Johor area, which is basically found at Parit Haji Salleh, Broleh, Batu Pahat, Johor. The bamboo heterostachya is being selected because it can bend and be shaped without breaking [9].

2.3 Technique mixing BFRC

The design ratio is being determine by using mix design form (DOE form). Based on the mix design form, the amount of material such as fine aggregate, coarse aggregate, cement and water can be set. the value and amount given or produced through the design mix form calculation aims to ensure that concrete grade 30 can be produced successfully.

Design mix form also shows how many samples can be done for each mix. The Mixing of bamboo fiber in concrete mixing start after the mix of cement water aggregate blend well. The bamboo fiber will be spread into the concrete mixture and will be blend again for the fiber blend in with the concrete mixture. As being shows in figure 2

Figure 2 Measure the weight of fine aggregate

The quantity of bamboo fiber must be followed by the calculation or ratio that being decided that is 0.1%, 0.2 % and 0.3 %. After the blend well of bamboo fiber the concrete mixture will being pour into the mold of cube size 100mm x 100mm and cylinder that size 100mm x 200mm

The characteristic of bamboo fiber that was the length of bamboo fiber 30mm and the ratio that being used were 0%, 0.1%, 0.2%, and 0.3%. The determined ratio was being set based on the previous study that was “Influence of Length Variation in Bamboo Fiber on Tensile Strength and Compressive Strength of Concrete” author by Trimurtiningrum, R., Faziz, F., & Lendah, L in 2019. This study used hard bamboo fiber and it show the result slightly increases of tensile strength compared with control sample, while the ratio that being used in the research is 2%. So based on this, the research that being conducted would be used different percentage and ratio that were 0%, 0.1%, 0.2%, and 0.3% to determine the workability, compressive strength and tensile strength of the concrete.

2.5 Testing

Testing for workability, strength and compressive strength to be chosen properly to test every characteristic of the concrete; the right testing will get the result that being research

2.5.1 Slump test

Slump test need be proceed after the concrete mixing was well mixed, record the measurement of slump test value.

Figure 3 The measurement of workability

2.5.2 Compressive test

The compressive test starts with taking out the sample from the curing tub then the weight of sample will be measure for calculation for compression strength. Then after the weight being record the cube sample will be compress and the max load of the sample will be recorded. Table 2 show compressive test.

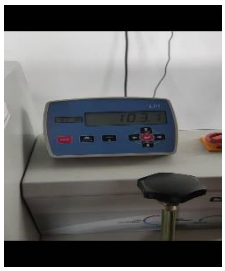
Table 2 Compressive test

Table 2	Description
	Recorded the weight of cube sample
	Compress the cube sample to determine the max load of the sample
	The max load of the sample recorded

2.5.3Tensile strength

Split test or tensile test is a method for determining behaviour of materials under axial tensile loading. The tests are conducted by fixturing the specimen into the test apparatus and then applying a force to the specimen by separating the testing machine crossheads. The crosshead speed can be varied to control the rate of strain in the test specimen.

Table 3 Tensile split test for cylinder samples

Table 3	Description
	Sample of cylinder of 0%,0.1%,0.2% and 0.3%
	Measure the weight of cylinder sample
	Place the wood stick that being prepared and place it on the top and bottom from max load cylinder test
	The max load data for cylinder recorded

3. Results and Discussion

The result that being conduct in the research to achieve the objective is slump test, compression test and tensile split test. The test being run is to find the workability of the concrete, the strength of the concrete and the tensile strength of the concrete, this test is being conduct is to observe the change concrete characteristic due to adding of bamboo. The bamboo is being choose for the additional material because of bamboo has a strong tensile strength.

3.1 Workability

The slump value decreases from 108 mm for control sample to 87mm for 0.3 % bamboo fiber content. Below shown the table and figure of slump value corresponding with the bamboo fiber content adding to the concrete.

Table 4 Slump value for each fiber content adding

Fiber content (%)	Water cement ratio	Slump (mm)
0 %	0.49	108
0.1 %		99
0.2 %		93
0.3 %		87

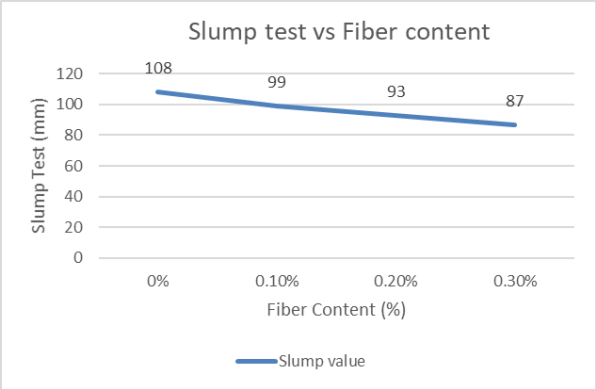


Figure 4 The variation of slump value with the change of bamboo fiber

3.2 Compressive strength

Based on the result of the compression test, the compressive strength for the 7-day curing shown that the increases of strength from control sample 21.863 N/mm^2 with 0 % fiber content to a maximum value of 29.923 N/mm^2 with 0.1 % fiber content. While for 28-day curing, the compressive strength that being shown for control sample is 30.710 N/mm^2 and the rest fiber content sample for 28-day shown more adding of fiber content to the concrete th decreases and less value of tensile strength will be obtain from the control sample with is 0% fiber content.

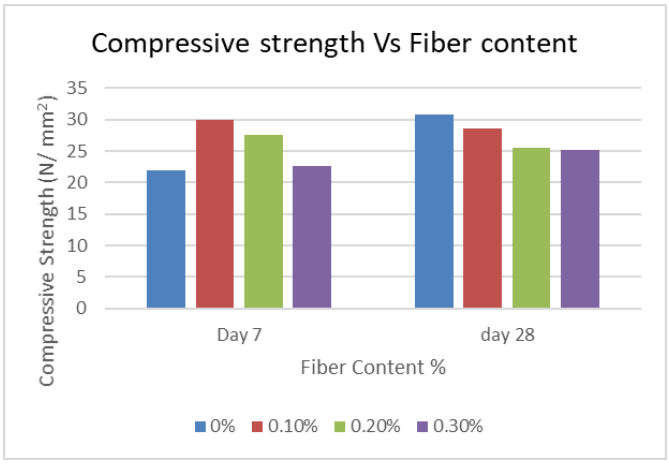


Figure 5 The comparison of compressive strength for the concrete

The formula that being used to calculate the compressive strength is

Compressive strength (N/mm^2) = Max load (N) / Cross Section (mm^2)

3.3 Tensile Strength

Referring to tensile strength that being conduct, the result shown that the decreases of tensile strength. The more adding of bamboo fiber the less the tensile strength be shown than the control sample which is 0 % that is 3.098 Mpa. The higher strength between the adding ratio for the tensile strength is for 0.1 % that is 3.080 Mpa close to control sample value.

The formula that being used to calculate the tensile strength is

Tensile Strength (Mpa) = 2(Max Load (N)) / π x D (mm) x L (mm)

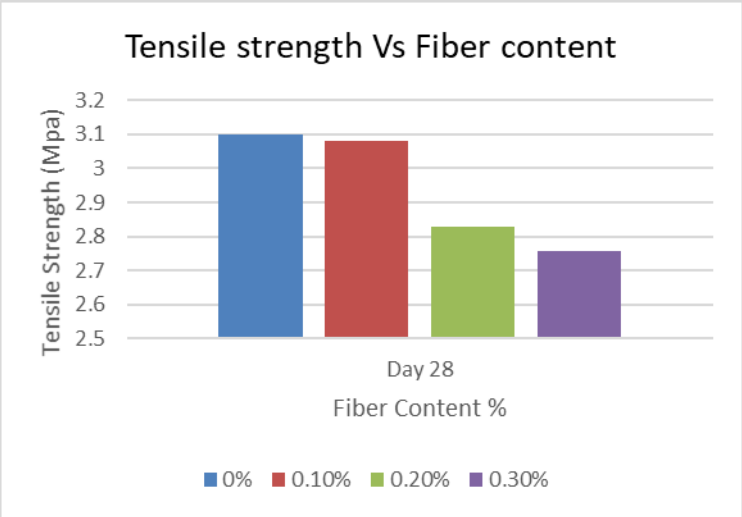


Figure 6 shown the bar chart of tensile strength of the concrete

The average strength for control sample that is 0% 3.098 N/ mm^2, average strength for 0.1% is 3.080 N/ mm^2, 0.2 % is 2.828 N/ mm^2 and lastly for 0.3 % 2.757 N/ mm^2. The minimum percentage for compressive strength of the concrete for 28 day is 99 percent referring to figure 3.30, from this result it shown that the control sample is the highest value of tensile strength then it slowly decreases, the decreases happen due to over adding or too much of bamboo fiber in concrete. 0.1 % show a slightly different from control sample, and can be conclude that more bamboo fiber may reduce the tensile strength. Based on the previous study that show the increases of tensile strength due to adding of bamboo fiber, can be because of the bamboo physical type that is hard bamboo fiber or stick bamboo fiber while for this research the bamboo fiber is soft and flexible.

3.4 Comparison between current study and precious study

The result of the test from the current research were being compared, the value or data that being used in the comparison section will be the optimum data of every test and the end of the 28 days which is the maximum strength of concrete.

Table 5 Comparison between current study and precious study

Research		Workability	Compressive strength	Tensile strength
Previous study				
Trimurtiningrum, R., Faziz, F., & Lendah, L	Influence of Length Variation in Bamboo Fiber on Tensile Strength and Compressive Strength of Concrete	95 mm	23.003 N/mm^2	10.312 N/mm^2
Current study				
/	Bamboo Fiber as Enhancement Material in Concrete	99 mm	28.613 N/mm^2	3.080 N/mm^2

Comparer between the previous study and current study which the previous use hard bamboo fiber while current use soft bamboo fiber, it shows that the workability of current study which is 99mm was higher than the previous study which was 95mm. while for the compressive strength both were to be expected decreases, the value was 23.003 N/mm^2 and 28.613 N/mm$^{2.}$ Lastly. The tensile strength from previous study was high with the value of 10.312 N/mm^2 compare with 3.080 N/mm2 which is lower but still passing the BS standard. This can be concluding that using bamboo fiber surely can increase the tensile strength.

4. Conclusion

This research concludes that the use of bamboo fiber in reinforcement concrete that produces bamboo fiber reinforcement concrete (BFRC) can achieve and meet the objective of the study which is to formulate and determine the workability for the content of bamboo fiber in reinforcement concrete, therefore this study will use the quantity of bamboo fiber that different to be mixed into reinforcement concrete. For the result show an improvement from the control sample. The objective of this study is also to identify changes in reinforcement properties of concrete caused by bamboo fiber mixture. The changes that likely will be focused for the inspection of strength and tensile strength. The result show that there are decreases in compressive strength and the same as tensile strength

The research shows that the workability of concrete value for the BFRC is low than the standard concrete value G30 that being calculated. Based on the research even though the workability BFRC is lower than the standard reinforcement concrete, the value for all BFRC is still pass the standard value for reinforcement concrete that is around 60mm to 180mm slump value. It can be concluded that BFRC workability is passable.

Based on the research by adding the bamboo fiber into reinforcement concrete and create bamboo fiber reinforcement concrete (BFRC) show that the compressive strength for twenty-eight days is less than the grade that being set that is concrete G30. The test shows that the more quantity of the bamboo fiber in concrete, the less the compressive strength of the compressive. The decreasing of compressive strength is expected by observing the previous research.

Tensile strength is the strength that consider as most important aspect in concrete design, it shows the concrete overall strength, in general the tensile strength of concrete is higher when cement content is high. Based on this research it shows that BFRC value for tensile strength low than the control sample value but for the 0.1 % bamboo fiber content, the value shows only slightly lower different from

the control sample. This proof that from the previous study where it shows the increases of tensile strength is true and there is a certain optimum content of bamboo fiber where it has high tensile strength.

There are a few recommendations for this research that can be done in the further study for the improvement of the sample

i. Use different type of bamboo in the research, try to use the bamboo that have more tensile strength properties.

ii. Use different length and percentage in concrete mixture, such as reduce the bamboo adding or increase the concrete grade.

iii. Using different physical of bamboo fiber, instead of using soft bamboo fiber, try to use hard bamboo fiber.

iv. Make sure to involve the water content in the bamboo while doing water cement ratio for concrete to avoid additional of water in mixture.

v. Add the various of other concrete testing beside compressive and tensile test.

vi. Reduce the bamboo fiber content pour in the concrete mixture.

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