

A Review on the Used of Bamboo as Aggregate in Concrete with Different Type of Treatment

Nur'Ain Idris^{1,*}, Hamidun Mohd Noh², Muhammad Fahmi Md Zor¹, Nur Shazrina Abdul Wahab¹

¹Civil Engineering Department, Center for Diploma Studies,
Universiti Tun Hussein Onn Malaysia Pagoh Campus, Pagoh, 84600, MALAYSIA

²Faculty of Technology Management and Business,
Universiti Tun Hussein Onn Malaysia, Batu Pahat, 86400, MALAYSIA

*Corresponding Author Designation

DOI: <https://doi.org/10.30880/mari.2021.02.02.009>

Received 25 April 2021; Accepted 16 March 2021; Available online 30 May 2021

Abstract: The exploring of this study was collected from the previous research that focused on bamboo that sensitive with moisture depending on its environment. The treatment of bamboo before being aggregated are given priority. Methodology of study was descriptive and qualitative which include review of literature on properties, proportion, design and treatment of bamboo. From the result it is conclude that there are some properties of bamboo that help to strengthen the concrete. However, the problem can be overcome by treating the bamboo before mixing it in the concrete. Epoxy is found as a suitable treatment for bamboo and the design of the bamboo into pieces with a cut size of 2 to 4 cm length, 1 to 2 cm breadth and 1 cm thickness lead to good results. After analyzed all of the result, the best percentage of bamboo to be added into the concrete was between 5 -15 percent.

Keywords: Bamboo, Aggregate, Percentage, Size, Treatment

1. Introduction

Concrete is a construction material composed of cement, fine aggregates and coarse aggregates mixed with water which hardens with time. It is a mixture material composed of coarse mixture material encircled during an onerous matrix of cement that fills the gap among the mixtures particles and cements them along. It is wide used material within the housing industry. There are three basic part of concrete which is water, sand or gravel and cement. The careful balance of cement to water is needed once creating concrete. Mixture is one among the necessary constituents that have result in strength development within the theory that the gaps of coarse mixture is stuffed by the fine mixture, and also the gaps of fine mixture is stuffed by the binding materials. Additionally, the strength of concrete in the main depends on water or cement magnitude relation, mixture gradation, and mixture size and form, cement quality, common mixture time, common mixture ratios and curing. Bamboo is a plant derived from the clumps of grasses with cavities and segments. It is simply breed well. The plant is easily cultivated and productive, as a result of its high rate of growth, it can grow about 3 to10 cm per day.

Bamboo is commonly used in joined of the building materials. Bamboo are often utilized as building part like pole, beam, floor, wall or partition, ceiling, roof, buffer roof and door. In Asia, bamboo is sort of common for bridges stages and houses.

2. Methodology

This study has been undertaken as systematic literature review (SLR) to collect the data and results from previous study. It will explain more about the preferred required report paper. There are three phases will be will be focus on such as identification, screening and eligibility process. For more understanding about the phase to achieve the goal of this review, the flow diagram of the process carried out as shown in Figure 1.

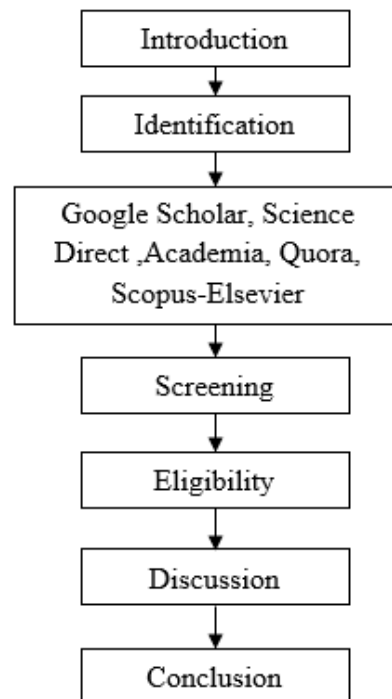


Figure 1: Flow Chart

2.1 Resources

This study used several platforms to find out the information and answering the objectives. The objective was focused on determination the percentage of bamboo as aggregate in concrete. It is also related with the size of bamboo as aggregate in concrete. Types of bamboo treatment as aggregate replacement in concrete also effect the compressive strength of the concrete. In this systematic literature review, the platform that used to find journals and conferences is Google Scholar, Science Direct and other source. Google Scholar is a great platform to find journal for references in making systematic literature review. Science Direct also a great platform because it is user friendly and accessible. Other than that, other source has been used in this systematic literature review but mostly of the journal is from Science Direct and Google Scholar.

2.2 Systematic Review Process

The systematic review process is the method that is used manually to evaluate the findings in such studies. Three phases are being taken in this part to finalize the best and most specific research required. Identification, screening and eligibility are the phases. All the data and information obtained from the review the paper will be reported and displayed in table form.

i. Identification

Table 1: Similarity Word

Similarity Word
Dendrocalamus Asper, Betong/Betung bamboo, bamboo
Aggregate, gravel, course aggregate
Treatment, curing, treated, protection, preservation

ii. Screening

Defines the search criteria used in the systematic analysis to identify relevant and appropriate papers.

Table 2: Inclusion and Exclusion Criteria

Criterion	Inclusion	Exclusion
Literature Type	Indexed Journal (research articles)	Non-indexed journals, Systematic review journals, chapter in book, conference proceeding
Language	English, Bahasa Malaysia	Non-English (except Bahasa Malaysia)
Time Line	Between 2000 - 2020	-

iii. Eligibility

The source of bamboo-related research as a limited aggregate is that the scope of the study should not be too small. Any studies related to "Betung/Betong bamboo or Dendrocalamus Asper bamboo or any bamboo", "bamboo and concrete", "bamboo treatment" and "bamboo in construction".

iv. Data Analysis

From the journals listed, all the review papers were selected using variation of mediums. Then, for the screening phase, general data regarding the database about this study was extracted to easier the collection of data. The general data collected using the suitable medium such as Scopus-Elsevier. Next, the study continued to focus on the objective. After that, eligibility phase was carried out to exclude the unnecessary data from screening phase to fulfil the objectives of this study. The data of the selected papers were classified according to each criterion to show:

- The properties of bamboo.
- The suitable type of bamboo treatment that can protect the bamboo from absorbing water in concrete mixing process.
- The specific size and shape of bamboo aggregate that can increased the compressive strength of concrete.
- The suitable concrete proportion that can be mixed with bamboo aggregate to be used in concrete design.
- The suitable percentage of bamboo than can be used in concrete design.
- The suitable design of bamboo to be used in concrete design.

3. Results and Discussion

3.1 Results

Table 3 : Summarization of Previous Paper

No	Title	Author	Adaption Strategies Suggested
1	A Study on Bamboo as A Replacement of Aggregates in Self Compacting Concrete	Dudhatra, Bhautik[1]	<p>-Traditionally steel is used as reinforcement in concrete structure. But because of cost and availability, replacement of steel with some other suitable materials as reinforcement is now a major concern.</p> <p>-Bamboo is a natural, cheap and also readily available material</p> <p>-Determining the various physical and mechanical properties</p> <p>-Pieces of bamboo used as a partial replacement of coarse aggregate</p>
2	A Bamboo Treatment Procedure: Effects on The Durability and Mechanical Performance	Bui, Quoc-Bao Grillet, Anne-C Tran, Hoang-Duy[2]	<p>-Sensitivity to moisture and their durability are usually questionable</p> <p>-Oil-heated treatment with different types of oils, like flax or sunflower oils to decrease their sensitivity to moisture and improve their durability</p> <p>-Treatment at 100 °C or 180 °C; with flax oil, sunflower oil, palm oil, soybean oil or without oil; treatment durations of 1 h, 2 h, or 3 h; and, different cooling methods and cooling durations</p> <p>-The best results were observed on specimens treated at 180 °C during 1 h or 2 h without oil, and then cooled in 20 °C sunflower oil.</p> <p>-Test: Effects of Oils-Treatments on the Bamboo Appearance and Weight.</p>
3	Study on Behaviour of Bamboo as Reinforcement with Coconut Shell as Aggregate Concrete in Compression Member with Different Lengths	Daniel, A Joshua Avula Ganesh Reddy A.Joshua Daniel [3]	<p>-Treated with water repellent substance like epoxy</p> <p>-Replacement of aggregate and reinforcement</p> <p>-Performed the test on the short columns with different types of reinforcement under axial loading</p> <p>-The bamboos used as reinforcement in this study were treated as the research shows treated bamboo have better performance compared to the untreated bamboo. Research has also proved that the column containing untreated bamboo shown less ductility than that of the bamboos with treated bamboo.</p> <p>-Treated bamboo with binding wire.</p> <p>-Used a treated bamboo</p>

			<ul style="list-style-type: none"> -Used proportion 1:1:47:0.65 and water cement ratio 0.42 -The size of bamboo used as aggregate was made to 12mm -Stiffness of the column decreased with the replacement of coarse aggregate -Stiffness of the column with bamboo reinforcement was lesser than the column with coconut shell aggregate and reinforcement. -The ultimate load carrying capacity of the columns decreased with the increased in the length.
4	Experimental Investigation on Concrete using Bamboo Fibre as Partial Replacement for Course Aggregate in Concrete	Pandey, Brajesh Kumar, Vikash[4]	<ul style="list-style-type: none"> -Replacements of reinforcing bar in concrete -The experiment use bamboo fibre on compressive and flexure strength -Further singly and doubly reinforced beam with bamboo sticks have been cast and tested in flexure -Increase in the flexural strength and Modulus of elasticity of bamboo reinforced beam -Coarse aggregates can be replaced with coarse bamboo pieces.
5	Experimental Study on Partial Replacement of Coarse Aggregate by Bamboo and Fine Aggregate by Quarry Dust in Concrete	Maran, Mani Ravichandran[5]	<ul style="list-style-type: none"> -Replacement of coarse aggregate used in concrete -Compressive strength, flexural strength, split tensile strength and durability characteristic -A thin layer of epoxy solution on the surface and it is trailed by covering of fine sand. -The fine aggregates were replaced by quarry dust -To achieve the workability of concrete the super plasticizer was used

3.2 Discussions

i. Bamboo Propertise

Bamboo is the fastest growing plant in the world having growth up to 60 cm or more in a day. Bamboo has social, economic and cultural significance and is used extensively for building materials along with thousands of uses. It is highly versatile raw material for different works. The bamboo is light weight, flexible, tough, high tensile, cheap material than the other building materials like steel. Bamboo can be used in various building works. Bamboo structures are flexible, earthquake resistant, light weight and cheap. Bamboo can be used as reinforcement in various structural members. Bamboo is a green material for sustainable development and has various advantages. Based on **Table 4**, tensile strength is mostly stated by the researcher when they applied test on the bamboo. Bamboo also high in term of flexural strength when added into concrete. However, uncoated or untreated bamboo has high problems when it relates to water absorption. It is because it has high number in term of moisture content. Bamboo

also has a great durability when it was made into reinforcement in beam concrete. Bamboos have social, economic and cultural significance in East Asia and South East Asia and are used extensively for building materials, food source and as a highly versatile raw product. The bamboos have good bending strength and flexibility. The height of bamboo plant can go up to 40 m and it still stands against the wind pressure.

Table 4: Bamboo Properties

Bamboo Properties	Number of Research Papers
Tensile Strength	7
Flexural Strength	2
Water Absorption	4
Moisture Content	1
Durability	1
Total	15

ii. Bamboo as Aggregate

Table 5: Design of Bamboo for Used in Concrete

Design of Bamboo for use in Concrete	Number of Previous Study Used
Bamboo Pieces (Like Aggregate)	7
Bamboo Raw Shape	8
Bamboo Fibre	7
Bamboo Powder	0

This part shows the result of the design of bamboo for used in concrete. As shown in **Table 5** these results were classified into four design which are the bamboo cutting into pieces, bamboo raw shape, fibre and as powder. From the **Table 5**, bamboo raw shape is the most applied with researcher. With the raw shape, the bamboo commonly can be applied as the long shape i.e. beam, column, reinforcement and scaffolding. Sometimes, bamboo was used as mixture, additional or as replacement in concrete design. Several previous papers have used bamboo pieces in concrete as additional to reduce proportion of aggregate as shown in **Figure 2**. While, there also have previous paper that study about bamboo fibre as sound absorber wall.



Figure 2: Bamboo Pieces (as Aggregate)

Based on **Figure 3**, most of the researcher used a normal proportion which is 1 : 2 : 4 to mix the concrete and bamboo. There is only one researcher used bamboo as addition in the concrete while five researcher used bamboo as replacement in their concrete thus it gives a various result of the data. Next, two researcher used treated bamboo while three researcher used untreated bamboo as aggregate in their concrete. However, the treated bamboo data results give a higher compressive strength compared to the untreated one. Three researcher used bamboo with addition of other substances in their

concrete. Example of the other substances are fly ash, coconut shell and quarry dust. However, addition of the other substances makes the concrete compressive strength higher compared to the one without any addition. Most of the researcher used five to fifteen percent bamboo percentage in the concrete. There is one result where the replacement of five percent of bamboo in aggregate gives a higher compressive strength compared to the standard concrete.

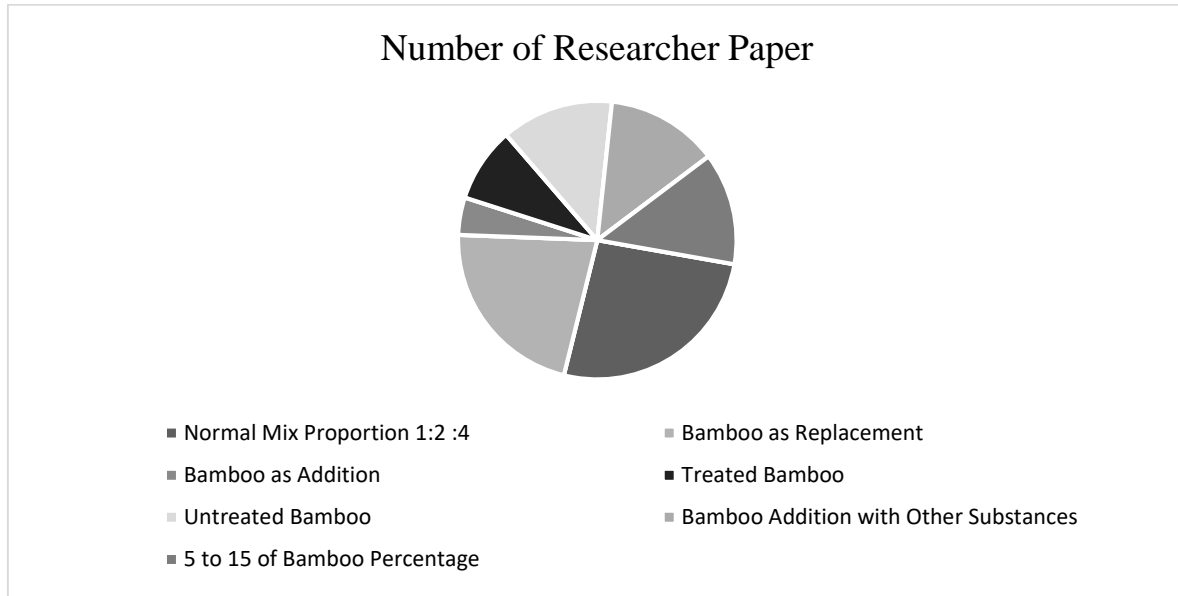


Figure 3: Chart of Bamboo as Aggregate in Concrete

iii. Bamboo Treatment

Figure 4 shows the different type of treatment against the number of previous studies used. This summarization has been done after study all the previous research paper. There are several types of treatment used from the previous study. From the result as shown in **Figure 4**, untreated bamboo mostly used by the researcher from previous study as main component to make a comparison with treated bamboo. Untreated bamboo as control component to make a comparison quality with treated bamboo. The mostly treatment used by the researcher is epoxy and combination of borax and boric acid. Epoxy was used because it can avoid from water absorb and significantly improves the tensile, flexural and impact properties of bamboo [6]. Epoxy adhesives provide water resistance, durability, chemical resistance and thermal resistance. They provide a tough, protective coating, with outstanding hardness. Other than that, Epoxy-based nanocomposites were prepared by incorporating Cellulose Nanofibers (CNF). The influence of the CNF as a reinforcement material on the morphology, and therefore the physical, mechanical, and thermal properties of epoxy-based nanocomposites were investigated using Scanning Electron Microscopy (SEM), density, void content, water absorption, tensile, flexural, impact strength, and thermogravimetric analyses. Compatibility between the Nano-reinforcement and epoxy matrix was confirmed using SEM. Moreover, the incorporation of CNF into the composites reduced the water uptake of the substrates within the water absorption test and resulted in a very high thermal stability when exposed to a heat. Bamboo-CNF may be used as a possible reinforcement material to enhance the properties of epoxy-based nanocomposite [7]. From This result, it can be concluded epoxy was the best type of treatment that can be used in future.

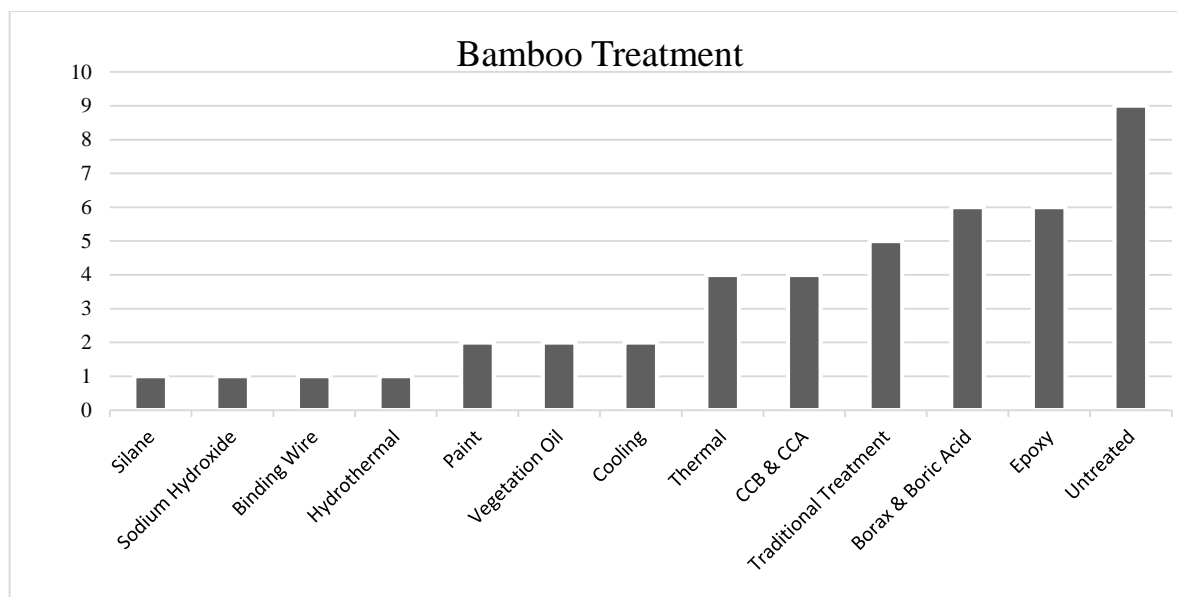


Figure 4: Treatment Used from Previous Study

4. Conclusion

This study had reviewed the journal to achieve the objectives stated. All the objectives were successfully achieved. The first specific objective was to determine the percentage of bamboo as aggregate in concrete. Five to fifteen percent is the percentage that usually used by researcher to mix the aggregate with bamboo aggregate. The second specific objective was to determine the size became more effective when the minimum size of varying length from 2 to 4 cm, breadth from 1 to 2 cm, and thickness of 1 cm. The last specific objective was to proposed the best treatment of bamboo as aggregate replacement in concrete also achieved where the optimum result reached if used epoxy as the treatment. However, there is one research paper stated that using bamboo as aggregate can decreased the compressive strength of concrete, but the researcher did not apply any treatment to the bamboo. It can cause the bamboo to absorb water in the mixing of concrete process. Thus, it decreased the compressive strength of the concrete as the water that needed in concrete was absorbed by the bamboo. Next, bamboo that did not treated or preserved well, it could absorb water from surrounding that can promote the growth of mould on the bamboo. Then, it could also affect the effectiveness and physical properties of bamboo. The result was reached by discussed and compared the result from previous study to choose the best criteria in producing concrete.

Acknowledgement

This research was made possible by funding from Fundamental Research Grant Scheme Vot. No. K315 provided by the Ministry of Higher Education, Malaysia. The authors would also like to thanks the Centre for Diploma Studies (CeDS), University Tun Hussein Onn Malaysia for its support.

References

- [1] B. Dudhatra, "A Study on Bamboo as a Replacement of Aggregates in Self Compacting Concrete," vol. 6, no. 05, pp. 429–432, 2017.
- [2] Q. Bui, A. Grillet, and H. Tran, "A Bamboo Treatment Procedure : Effects on the Durability and Mechanical Performance," pp. 1–11, 2017, doi: 10.3390/su9091444.
- [3] A. J. Daniel, "Study on Behaviour of Bamboo as Reinforcement with Coconut Shell as Aggregate Concrete in Compression," no. 1, pp. 1–4, 2015.

- [4] B. Pandey and V. Kumar, “Experimental Investigation on Concrete using Bamboo Fibre as Partial Replacement for Course Aggregate in Concrete,” vol. 4, no. 07, pp. 56–58, 2016.
- [5] M. Maran and P. T. Ravichandran, “EXPERIMENTAL STUDY ON PARTIAL REPLACEMENT OF COARSE AGGREGATE BY BAMBOO AND FINE AGGREGATE BY,” no. August 2017, 2018.
- [6] C. U. Maheswari, K. O. Reddy, E. Muzenda, and M. Shukla, “Effect of Surface Treatment on Performance of Tamarind Fiber – Epoxy Composites,” *Int. Conf. Innov. Chem. Eng. Med. Sci. (ICICEMS 2012)*, no. Hy 951, pp. 16–20, 2012.
- [7] S. Rizal *et al.*, “Enhancement of the physical, mechanical, and thermal properties of epoxy-based bamboo nanofiber nanocomposites,” *BioResources*, vol. 13, no. 4, pp. 7709–7725, 2018, doi: 10.15376/biores.13.4.7709-7725.