Recent Trends in Civil Engineering and Built Environment Vol. 4 No. 1 (2023) 213-219

RTCEBE

Homepage: http://publisher.uthm.edu.my/periodicals/index.php/rtcebe
e-ISSN :2773-5184

A Review on Bamboo as Natural Reinforcement in Concrete

Nor Syazwani Saadun[1], Masni A. Majid[2]*

[1]Faculty of Civil Engineering and Built Environment,
Universiti Tun Hussein Onn Malaysia, Batu Pahat, 86400, MALAYSIA

[2]Jamilus Research Centre, Faculty of Civil Engineering and Built Environment,
Universiti Tun Hussein Onn Malaysia, 86400, MALAYSIA

*Corresponding Author Designation

DOI: https://doi.org/10.30880/rtcebe.2023.04.01.022
Received 06 January 2022; Accepted 15 January 2023; Available online 01 May 2023

Abstract: Fibres are mainly used as a natural reinforcement in concrete. Bamboo needed quite some time before used and strong in strength. The cons properties of bamboo are easy attack by insects, fungi and high in water absorption. Bamboo must be treated to ensure the longevity of bamboo. Therefore, this study was about to investigate the physical and mechanical properties of concrete containing bamboo as a natural reinforcement compared to standard mild steel. The design addition of bamboo fibres with treated or untreated which 0.5%, 1.0%, 1.5% and 2.0% was evaluated. Overall, the bamboo fibres as reinforced concrete for 1.0% to 1.5% are the best ratio of mix designation that have significant increase in compressive and tensile strength that tested after 28 days of curing. Meanwhile, the density test for concrete is shown lower compared to mild steel fibres reinforced concrete. Treated bamboo by using chemical treatment improved strength and reduced water absorption more than 50% compared to untreated. Bamboo as reinforces in concrete are suitable for lightweight construction building.

Keywords: Natural Reinforcement, Bamboo Fibres, Concrete

1. Introduction

In today's world economy in construction industry, the cost of steel reinforcement bar is currently increasing. Since the main material for conventional material starting to become expensive, the total cost of construction will surely increase as well. Liu *et al*. [7] mentioned that, natural plant fibres are used due to their low density, mechanical properties with flexural, durability, sustainability and biodegradability. Natural plants have made direct contribution for economic prosperity and sustainability. Bamboo fibres have been used in variety of industrial applications, including textiles, paper and in construction. Bamboo fibres have recently regained popularity as a way to replace or reduce the use of non-renewable resources [1].

Identification of strategies aimed at reducing the building industry's environmental impact for greening the industry and achieving sustainable development goals. One way to reduce the effects

*Corresponding author: masni@uthm.edu.my

involve the ability to recycle waste materials, or using natural material in concrete reinforcement thus following the circular economy principles. Recent renewed interest in bamboo fibres that mainly aimed at replacing or reducing the use of non-renewable resources [2]. In general, bamboo has numerous potentials because it may be used for both production and conservation purposes.

Reinforced concrete is a mix of reinforcement and concrete that can be used in a variety of construction works. Concrete good in compressive but the tensile strength is low [11]. Fibres, particle or flake reinforcements [4]. Natural fibres added into fresh concrete can improve the ductility of the concrete matrix. Reinforcement's purpose is to provide additional strength to concrete where it is required. The strength of composite undoubtedly rise as the effectiveness of the reinforcing improves. Concrete without reinforcement is weak in tension and cannot withstand tensile and shear stresses caused by wind, earthquakes, vibrations and other forces, making is therefore unsuitable for most structural applications [5].

The tensile strength of the steel and the compressive strength of the concrete work together in reinforced concrete to allow the member to withstand these stresses over long distances. The tensile strength of the concrete is about ten percent of its compressive strength. The use of reinforcement in can leads to effective structural behavior because reinforcing steel works effectively under compression, limiting the compression reinforcement [7]. It was found that bamboo has lower bonding with concrete rather than steel. Bamboo's compressive strength was significantly lower than its tensile strength, with high strength along the fibres but low strength transverse to the fibres. It concludes that bamboo reinforced concrete is a potential low-cost alternative light construction method or simple building construction. They also commented on the advantage bamboo that has over other natural building materials with its fast growth rate. However, it was revealed that treated bamboo has improved the bamboo concrete bonding by with 90% [3]. It was discovered that, when compared to steel, the bonding between bamboo and concrete was weaker. The compressive strength of bamboo was much lower than tensile strength, and there was high strength along the fibres but low strength transverse to the fibres.

2. Materials and Methods

The review study is based on the bamboo fibres as reinforcement in concrete. Many studies of the review paper and proceedings have been conducted in order to achieve the aimed of the research. The finding from previous studies on chemical treatment, physical and mechanical properties was reviewed and analysed.

2.1 Materials

About 62 previous research paper were gathered and reviewed to determine the treated or untreated bamboo, water absorption, density, compressive strength, tensile strength and the flexural strength on bamboo as a reinforcement in concrete. The tested conducted after 28 days of curing and many types of bamboo are choose. The research papers were reviewed in range 2005 until 2021.

2.2 Methods

The research method were done by finding the journal and articles form previous studies that were relevant to this topic, which is "A Review on Bamboo Fibre as a Natural Reinforcement in Concrete". Those journal and articles will be reviewed thoroughly and the data obtained from the journals will be analyzed and discussed further. Work was researched to ensure that the research process was carried out in a systematic manner. In the first stage, the study was primarily focused on reviewing previous research studies on bamboo fibres as a reinforcement in concrete, with the benchmark being to compare steel fibres as reinforcement. Hence, the comparison and analysis were made to determine the treated or untreated bamboo, water absorption, density, compressive strength, tensile strength and the flexural strength on bamboo as a reinforcement in concrete.

3. Results and Discussion

The performance of concrete is examined in this study by looking its fibres chemical that are treated, the density, compression value and the tensile value. To obtain this result, several analyses had been

done which is chemical treatment analysis to determine the most preferred solution for bamboo fibre, density analysis to obtain the density of reinforced concrete, compressive strength analysis to obtain compression value and tensile strength analysis to obtain tension value.

3.1 Chemical Treatment

Most of the previous studies used alkaline, NaOH solution for bamboo treatment. About 38% used alkaline, followed by 13% of heat treatment waterproof treatment, 12% of rosin treatment, 8% of copper chrome boron with 8-10% solution. The others treatment shown the same percentage which is 4% are using soaking in water, boric acid, chromated phosphate and bitumen treatment. It was analyzed that alkaline solution; sodium hydroxide (NaOH) produced the best results when compared to other methods in improving the strength of bamboo fibres as a reinforcement in concrete and improving the mechanical properties [12].

3.2 Compressive Strength

This study shows that instability occurred to the compressive strength of concrete when fibers were added. Therefore, the addition of fibers in concrete does not improve the compressive strength of concrete, which is consistent with the reports by Lin *et al*. [6]. Based on the figure 1**,** the compressive strength of concrete containing bamboo as reinforced fibre shows lower strength compared to standard compressive of mild steel which is 250 N/mm². This is because the steel is strong in tension and compression compared to natural fibre such as bamboo [10]. However, the highest compressive strength of the reinforced bamboo is 93.16 N/mm² compared to standard compressive strength of mild steel with unmentioned percentage of bamboo it seems that the lowest compressive strength of bamboo as reinforced in concrete is 21.94 N/mm². However, the data shown are not accurate due to some factors such as type of bamboo used, age of bamboo, and different sizes in tested concrete. It can be concluded that, the percentage of bamboo fibres as a reinforcement in concrete are corresponding with their compressive strength.

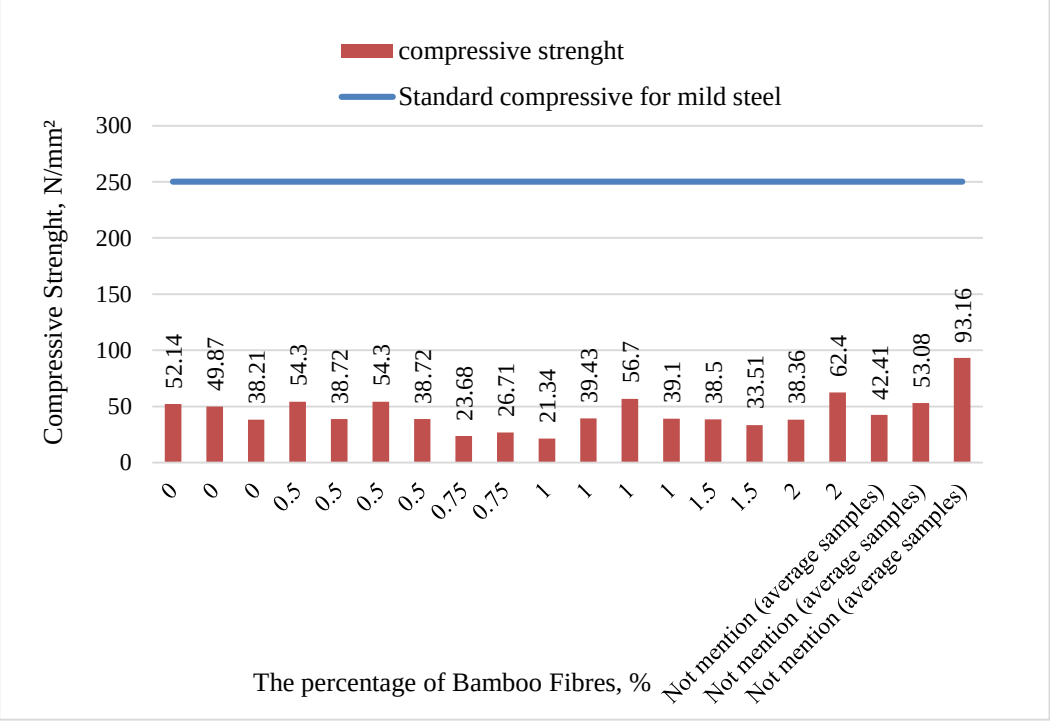

Figure 1: Analysis on Compressive Strength Bamboo Fibre Concrete

3.3 Tensile Strength

Figure 2 shows the analysis of tensile strength on Bamboo Fibre Concrete that tested after 28 days of curing. Proper chemical treatment is applied to half of the samples. The figure below clearly shows

that when bamboo is chemically treated, it shows an increase in strength when compared to untreated bamboo. The comparison between treated and untreated bamboo are proven in the figure where the same percentage of bamboo fibres which is 1% resulted in different tensile strength. However, the treated bamboo still cannot reach up the mild steel tensile standard which is 300 N/mm². The highest tensile strength of the treated bamboo is 176 N/mm² with unmentioned the percentage of bamboo fibres. While the lowest tensile strength of treated bamboo was 15.67 N/mm² with unmentioned percentage of bamboo fibres. The overall finding indicates that the right amount of bamboo fibres can improved in tensile strength but still cannot reach up to mild steel standard tensile strength.

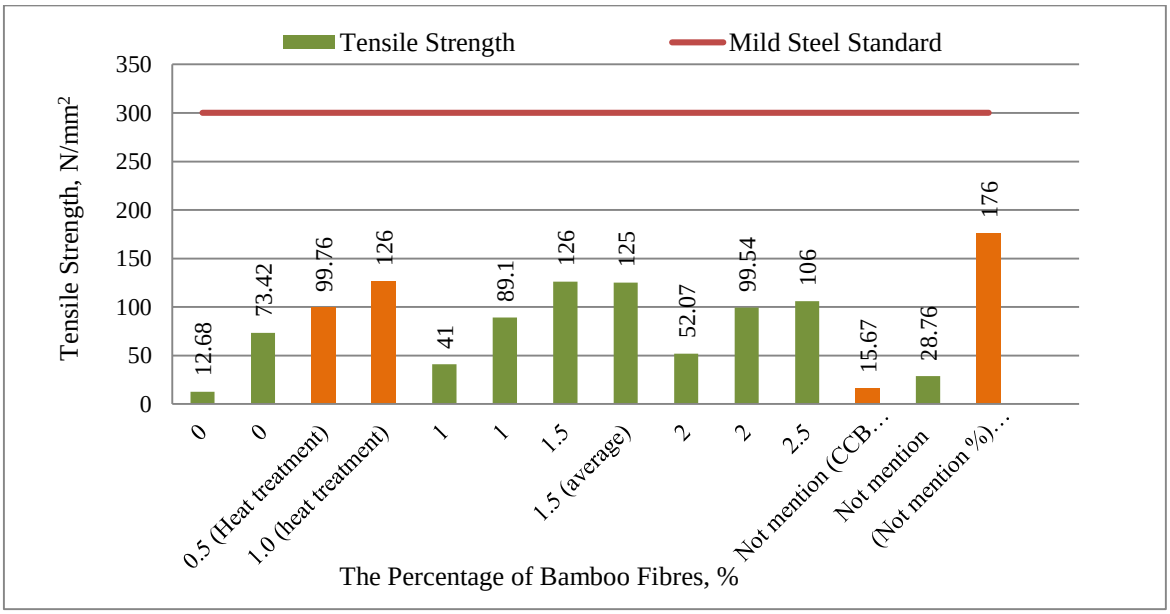

Figure 2: Analysis on Tensile Strength on Bamboo Fibre Concrete

3.4 Flexural Strength

The flexural test against the percentage of bamboo fibres that tested after 28 days of curing (Figure 3). It shows that most of the tested sample of flexural strength achieved the standard of mild steel in flexural strength which is 6.16 N/mm². It is demonstrated that the addition of bamboo fibres and the day of curing significantly increased the flexural strength [8]. The highest flexural strength achieved is 14.21 N/mm² compared to mild steel flexural strength with 1% of bamboo fibres. However, other samples 1% of bamboo fibres showed lower in flexural strength which are 4.42 N/mm², 7.75 N/mm² and 7.25 N/mm². This may due to some factors related to bamboo or mixture ratio in concrete. It can be concluded that, the value flexural strength depends on many factors that must be considered.

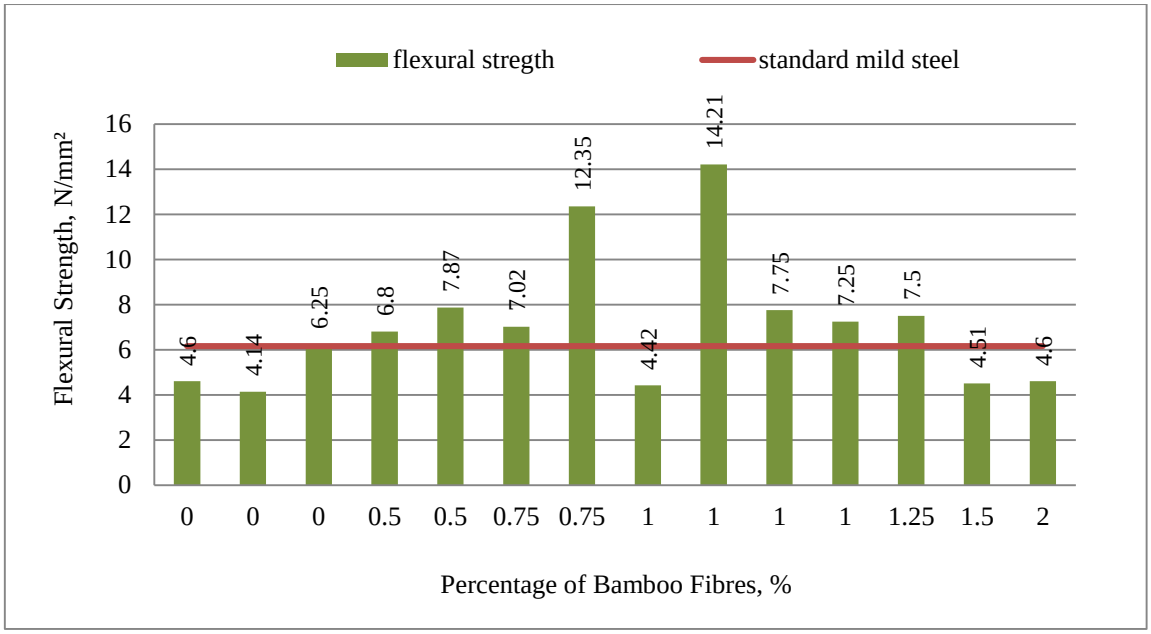

Figure 3: Analysis on flexural strength on Bamboo Fibres Concrete

3.5 Density

It can be concluded that, the density of bamboo fibres with percentages ranging from 0.75% to 3.0% does not reach the standard density of mild steel. This is because the fiber would absorb water and bind to hold the concrete together thus reducing the density of the concrete. The advantage of increasing the value of fiber is it is lightweight as the fiber are also cheap [9]. The mechanical properties of concrete are highly influenced by its density. Denser concrete generally has greater strength and fewer amount of voids and porosity. The used bamboo as reinforcement in concrete show low in density because bamboo are natural fibres that has high porosity thus resulting in high water absorption. It can be concluded that, the denser the concrete, the higher the strength [10-12]. Figure 4 shows the result obtained based on the several research.

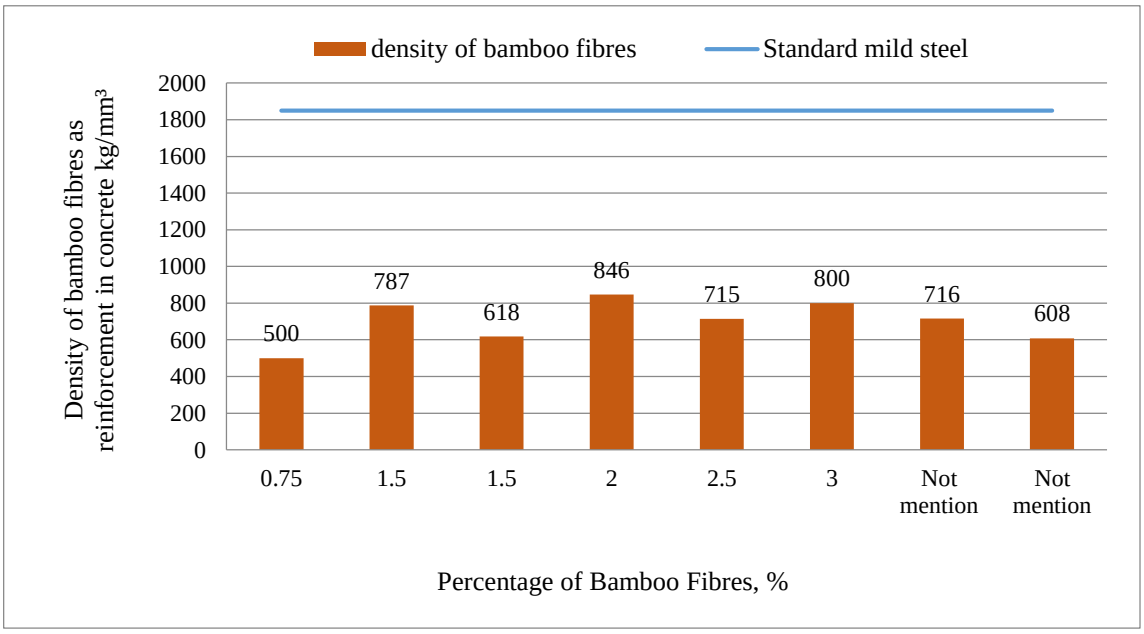

Figure 4: Analysis on Density of Bamboo Fibres Concrete

4. Conclusion

For concrete improvements, there are many research studies that had been done to increase strength, durability and performance of concrete itself. Some of the improvements were made by incorporating synthetic fiber into the concrete such as nylon fiber, polypropylene fiber, glass fiber and also steel fiber [5]. For this study, the aim was to review the performance of concrete containing bamboo fiber as synthetic fiber.

It can be concluded that the highest compressive strength is 93.16 N/mm² which is lower to standard mild steel which is 250 N/mm². The improved flexural performance of bamboo reinforcement concrete has been observed with the increase in number of days for curing period. Hence, the longer the curing process, the lower the water absorption. A very short period of curing caused the highest water absorption and it will be attributed to the higher porosity of the concrete. The increase in percent of fibres more than 1.5% has little effect on the compressive strength and may reduce the strength of concrete. Water absorption of bamboo is very high and chemical treatment are needed to minimize the water absorption during casting and in order to improve the bonding strength between bamboo and concrete. Treated bamboo with chemical treatment has improved the strength and reduced the water absorption more than 50%. The highest tensile strength is 176N/mm² which is lower than the standard of mild steel which is 300 N/mm². Bamboo as reinforced are suitable only for small construction building because the strength are lower compared to steel fibres reinforcement in concrete.

Acknowledgement

The authors would like to thank the Faculty of Civil Engineering and Built Environment, Universiti Tun Hussein Onn Malaysia for their support and assistance in making the smooth journey for this research to the end.

References

[1] Dewi, S. M., Wijaya, M. N., & Remayanti, N. C. (2017). The use of bamboo fiber in reinforced concrete beam to reduce crack. AIP Conference Proceedings, 2(10), 210-221.

[2] Farooqi, M. U., & Ali, M. (2018). Contribution of plant fibers in improving the behavior and capacity of reinforced concrete for structural applications. *Construction and Building Materials*, 182, 94–107.

[3] Ghavami, K. (2005). Bamboo as reinforcement in structural concrete elements. *Cement and Concrete Composites*, 27(6), 637–649.

[4] Karthe, M., & Manivel, R. (2020). Reinforcement of jute, net and epoxy composite. *Materials Today: Proceedings*, 21, 820–822.

[5] Kavitha, S., & Kala, T. F. (2016). Effectiveness of bamboo fiber as an strength enhancer in concrete Effectiveness of Bamboo Fiber as a Strength Enhancer in Concrete. *International Journal of Earth Science and Engineering*, 9, 1-14.

[6] Lin, Q., Huang, Y., & Yu, W. (2020). An in-depth study of molecular and supramolecular structures of bamboo cellulose upon heat treatment. *Carbohydrate Polymers*, 241.

[7] Liu, D., Song, J., Anderson, D. P., Chang, P. R., & Hua, Y. (2012). Bamboo fiber and its reinforced composites: *Structure and properties. Cellulose*, 19(5).

[8] Mali, P. R., & Datta, D. (2020). Experimental evaluation of bamboo reinforced concrete beams. *Journal of Building Engineering*, 28, 1092–1100.

[9] Nayak, A. (2013). Replacement of Steel by Bamboo Reinforcement. *IOSR Journal of Mechanical and Civil Engineering*, 8(1), 50–61.

[10] Shireesha, Y., & Nandipati, G. (2019). State of art review on natural fibers. *Materials Today: Proceedings*, 18, 15–24.

[11] Wahyuni, A. S., Supriani, F., Elhusna, & Gunawan, A. (2014). The performance of concrete with rice husk ash, sea shell ash and bamboo fibre addition. *Procedia Engineering*, *95(Scescm)*, 473–478.

[12] Xie, J., Qi, J., Hu, T., De Hoop, C. F., Hse, C. Y., & Shupe, T. F. (2016). Effect of fabricated density and bamboo species on physical–mechanical properties of bamboo fiber bundle reinforced composites, 15, 1-7.