Recent Trends in Civil Engineering and Built Environment Vol. 4 No. 2 (2023) 029-035

RTCEBE

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

Effect of NaOH Soaking Time for EFB Fibre Treatment on Tensile Properties of Single Fibre and Thermal Conductivity of EFB Cement Boards

Nawal Syahirah Abu Soid[1], Emedya Murniwaty Samsudin[1]*

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

*Senior Lecturer, Faculty of Civil Engineering and Built Environment, Universiti Tun Hussein Onn Malaysia

DOI: https://doi.org/10.30880/rtcebe.2023.04.02.004
Received 06 January 2022; Accepted 15 January 2023; Available online 20 July 2023

Abstract: Chemical treatment using sodium hydroxide (NaOH) becomes the most popular fiber pre-treatment used by many researchers. NaOH treatment on fiber however caused several drawbacks to the physical properties and the fiber's performance. The objectives of this research are to study the effect of EFB fiber on different NaOH concentrations and soaking time on the tensile strength and determine and compare the EFB cement board thermal conductivity based on different NaOH concentrations and soaking time. This was done by using various NaOH concentrations of 0 %, 1%, 3%, and 5%, percent with a preset soaking time of 1 and 3 hours. The ratio that been apply to the cement board is 3:1 (Fiber: Cement) and the cement board specification size is 150 ×150 × 13 mm for thermal conductivity test. Result on tensile strength of fiber shown that fiber with 5% concentration with 3-hour soaking time has the higher value that can carrying tensile loads. or thermal conductivity result shown cement board with EFB concentration 5% and 1 hour shown 0.00384 W/m^{oC}. of thermal conductivity and is suitable to be used as a thermal insulator. Hence, it can be concluded that the concentration and soaking time of EFB fiber in NaOH during pretreatment gave significant effects to the strength of the strand and thermal conductivity of EFB cement board. For the tensile strength of the fibers shows the fibers with a concentration of 5% with an immersion time of 3 hours have a higher value that can bear the tensile load of 0.3235 kN/mm^2.

Keywords: EFB Cement Board, EFB Fiber, Tensile, Thermal Conductivity.

1. Introduction

Palm oil provides most of the oil for worldwide trade, and demand continues to rise as the world's population grows. The focus of this research was to find the optimal pretreatment and the conditions that would allow all sugars liberated from cellulose and hemicellulose to be recovered. Chemical

*Corresponding author: emedya@uthm.edu.my

pretreatment is to improve reducing sugar production, this research would investigate acetic acid, liquid hydrolysis, and sodium hydroxide (NaOH) pretreatment [1]. Researchers are currently looking for new alternative sources of lignocellulose materials to replace the usually applied fibers in the construction industry. According to the research, combining EFB fibers with cement can improve the capability and quality of bio-composite materials. EFB fibers are naturally occurring composites consisting mostly of brittle, crystalline cellulose microfibrils embedded in a soft, amorphous matrix of hemicelluloses and lignin, as compared to many other natural fibers [2]. Oil palm fibre recovered from EFB has been shown to be an ideal natural fibre for composite materials because Malaysia is one of the world's leading producers of palm oil and substantial EFB waste is available at all replanting mills. Because Malaysia is one of the world's major producers of palm oil and abundant EFB waste is available at all plantation mills, oil palm fiber recovered from the EFB has been demonstrated to be an appropriate natural fiber for composite materials.

There are several advantages of using EFB palm fiber one of which can improve the brittle fracture structure of the cement matrix and can reduce the density of cement board by 1500kh/m^3 and with that condition it will be easy to handle [3]. According to [1] OPEFB will usually be burned to obtain heat and energy yields or converted to lower value -added products for example, compost and mulch. the innovation of palm oil waste is brought advantages to the new changes of technology EFB is produced from crude palm oil waste, but it also contains other components such as oil palm fronds (OPF) [4]. Because of it, best solution to overcome this environmental issue is by looking for alternative materials especially convertible natural fibers and this innovation gained new interest in the construction industry [5].

This research will aid in determining the strength qualities of EFB fiber and EFB cement board with EFB content that have been treated with a chemical pretreatment approach involving the use of sodium hydroxide (NaOH) at a specific concentration. However, extending the pretreatment period except for the final liquor pH was sufficient to reprecipitate previously dissolve hemicellulose, therefore employing alkali to improve the strength of EFB materials may result in a decrease in yield [6]. The best percentage of this mixture will have satisfactory tensile strength and thermal conductivity. An employing EFB fiber as a cement board will save money while also protecting the environment from waste disposal and pollution. Furthermore, by employing this strategy, this research can help to enhance the notion of sustainable construction and contribute to the development of new revolutionary building materials.

2. Assessment of Concrete Structure

Empty fiber brunch is one of the natural fibers and it is an environmentally friendly and biodegradable material that is abundant around the world lignin. There are several advantages of using EFB palm fiber one of which can improve the brittle fracture structure of the cement matrix. Chemical pretreatment is easy and energy efficient as compared to other methods. Acids and bases dissolved in bio-scrubber effluent may affect hemicellulose and lignin removal from EFB. For thermal insulation purposes, the material's thermal conductivity was critical. Heat moves more quickly through products with a higher conductivity. Thermal insulators, on the other hand, can be made of materials with a lower conductivity [7]. The use of waste as an additive resulted in a significant reduction in thermal conductivity Meanwhile, for tensile strength shows that NaOH treatment affects the surface morphology of fiber, affecting their characteristics. Tensile strength was reduced in alkali-treated fibers due to damage caused by a chemical structure shift in which crystalline cellulose in the fiber was largely replaced by lignocellulose material [8].

3. Materials and Methods

The materials that been used is EFB fiber, NaOH and cement for fabrication cement board. Methods of pretreatment that been selected is soaking the EFB fiber with selected concentration presents of NaOH which is 0, 1, 3 and 5 with each soaking time 1 and 3 hour. After the soaking process, the fiber will be dried by natural sun light and Ele heavy duty oven at temperature 100 ^{o}C for 24 hours. The

fabricated of EFB cement board are being curing for 28 days. There are 2 types of samples have been made that is EFB fiber for tensile strength and EFB cement board for thermal conductivity. For cement board sample size been made at size 150 × 150 × 13 mm.

3.1 Preparing the sample

Each testing is prepared 4 sample for each concentration and soaking time. Thus, total sample for the fiber at all concentration and soaking time is 32 for tensile strength testing. While 32 cement board sample for all concentration and soaking time are been prepared for thermal conductivity cement board testing. After a pretreatment material process, first step is to be mixing the treated fiber with sodium hydroxide (NaOH) pallets, cement and water. The ratio of cement board that been select is 3:1.

From this study, there are several tests that will be involve recording, calculate, and analyze the specimens. This is for study the ideal and optimum measurement of sodium hydroxide (NaOH) manipulate the properties of the EFB in term of tensile strength and thermal conductivity of materials. The testing will be done at University Tun Hussein Onn Malaysia (UTHM) laboratory which is involved Instron Universal Testing Machine (ASTM D3379) for tensile testing and for thermal conductivity test conducted in accordance with (ASTM C177) Guarded Hot Plate.

3.2 Tensile strength

Tensile strength testing of composite specimens was conduct by Instron Universal Testing Machine using ASTM standard (ASTM D3379) for single fiber prefer Figure 1. The specimen is observed to break, and the highest stress (F max) and strain are recorded. Tensile testing equipment is conditioned at a load of 10 kN load strength to determine tensile strength with a drawl speed of 2 mm/min. The diameter of fiber is identified by using Digital Outside Micrometer. Average of fiber diameter will apply the tensile properties of fibers. The value of stress has been identified by the machine using Equation 1.

$$\boldsymbol{\sigma = \frac{Load}{A}} \quad Eq.1$$

Figure 1: Instron Universal Testing Machine (ASTM D3379)

3.3 Thermal conductivity test

For thermal conductivity testing the conducted in accordance with (ASTM C177) Guarded Hot Plate The steady state approach was used to determine the thermal conductivity of all experimental samples at room temperature. The unidirectional steady-state heat flow through the sample may be calculated using heat transfer equation of heat conduction Equation 2. This testing has been conducts by using a Single plate method. It been tested by Solteq model HE110 prefer Figure 2.

$$q = \textbf{Heat flow density } \left(\frac{W}{m^2}\right) \times \textbf{Area, } A(m^2) \; Eq.2$$

Figure 2: Solteq model HE110(Guarded Hot Plate)

4 Results and Discussion

This result is be compared with the other concentration value and soaking time of sodium hydroxide (NaOH) against the type of test that been conducted. The result is to produce value of tensile strength and thermal conductivity properties of EFB cement board and EFB fiber. Complete analysis according to the parameters used in controlling the effect of the percentage of sodium hydroxide (NaOH) and EFB fiber as materials for EFB cement board. Then, it is also expected that this research will be reduce the production of waste material in agricultural industry and the same time innovation for new material for engineering. Lastly, this research will develop the sustainable material concept. It is also expected to promote the reuse by-products materials as a source of replacement in the construction industry and hope it will save the environment.

4.1 Tensile stress testing

The tensile strength of fiber is produced by EFB as the result showed in the Figure 3, as it compared by the value of sodium hydroxide concentration and period of soaking time. It was resulted that the value of tensile for both soaking time and value of concentration is irregular. The result shown that the untreated fiber has the fiber have the poor value of tensile for both soaking times. Thus, it proves that treated fiber that removed binding that contain on such as lignin and hemicellulose resulted the value of tensile strength. It shows that the value is increasing in tensile value due to 1 hours soaking time as the diameter is decreasing. However, for the 3 hours soaking time is uneven. This situation may occur to the cellulose contain is high in the fiber although the concentration is high and the soaking time increasing.

The best result of tensile strength test of EFB fiber is 5 percent concentration of sodium hydroxide with 3 hours soaking time. The result showed, the value is 0.5235kN/mm^2 compared to 0.2705kN/mm^2 for 3 percent concentration of sodium. hydroxide with 1 hour soaking time. It shows a significant value difference between 2 different immersion times. The decreasing of diameter value of fiber resulted to the increasing of sodium hydroxide concentration value [2].

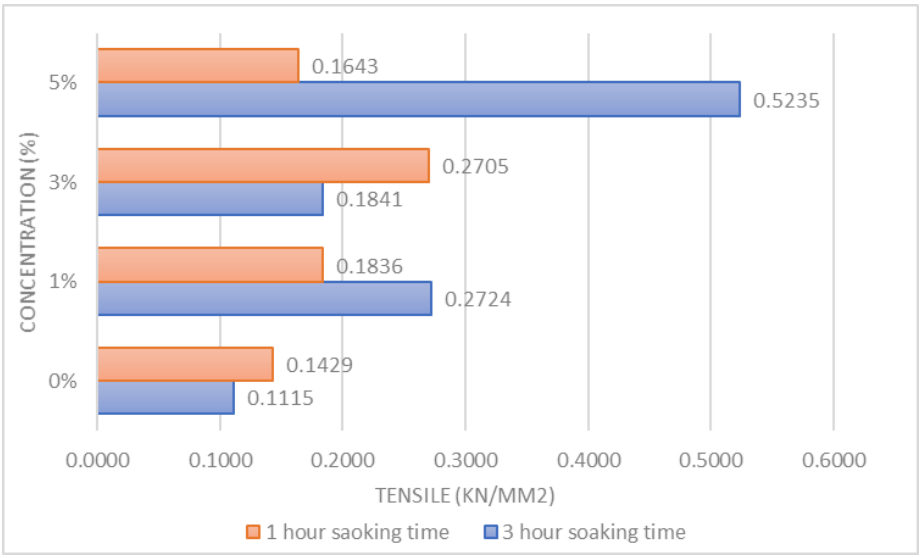

Figure 3: Effect of tensile strength by percentage of sodium hydroxide and soaking time

4.2 Thermal conductivity testing

The thermal conductivity of the EFB cement board is very important to insulation purposed. The material that has low value of thermal conductivity such as EFB is suitable to be used as a thermal insulator. The result shown that the thermal conductivity of the EFB cement board increasing by the value of concentration of 1 hour soaking time. However, the value of thermal for 3 hours of soaking time is decreasing along the increasing of concentration. The higher value of thermal conductivity is 5 percent of concentration of sodium hydroxide (NaOH) with 1 hour soaking time refer Figure 4. It resulted the the best value of thermal; conductivity of 5% soaking time with soaking time 1 hour which is 0.00384 W/m°C and as higher the concentration the increasing the value of thermal conductivity.

The result showed that the longer soaking time EFB cause the decreasing value of thermal conductivity and worst in thermal insulator of the materials [9]. This is caused of the damage of EFB physical properties that changing to the diameter of fiber due to the increasing of the concentration value and soaking time. The contain of cellulose is increasing as the fiber been treated within the present of lignin and hemicellulose is decreasing and pore is presence that cause the cement board has bad as insulation behavior. The higher of the thermal conductivity value effect to the improving of thermal insulation of the materials.

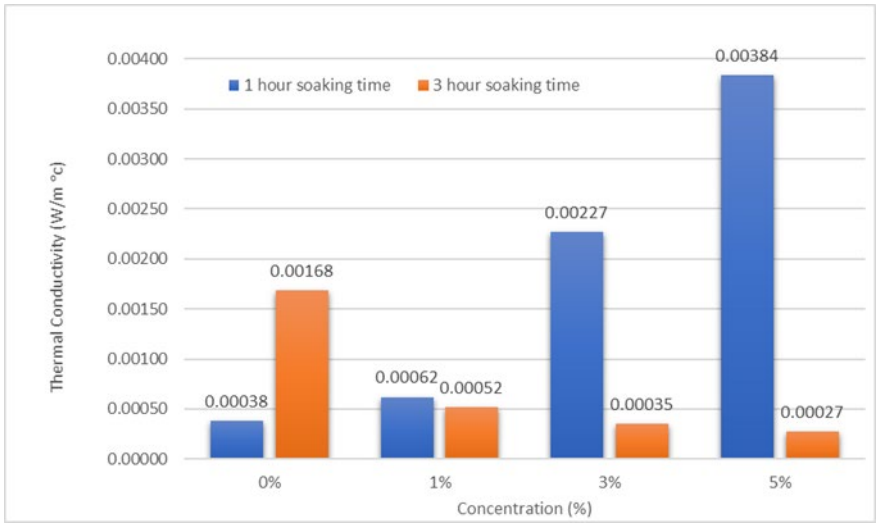

Figure 4: Effect of thermal conductivity by percentage of sodium hydroxide and soaking time

5 Conclusion

The workability of cement board on thermal conductivity properties is increasing along the concentration on 1 hour soaking time. However, it is decreasing in 3 hour soaking time. The best sample of thermal conductivity value is sample that been pretreated by sodium hydroxide for 5% concentration with soaking time 1 hour. The soaking time of 1 hour is suitable for the high concentration of sodium hydroxide with is align with the diameter and the fiber content. The contain of hemicellulose in the EFB is decreased and the existing of pore in the fiber result the value of thermal conductivity on the cement board is drop and bad in thermal insulation.

The usage of sodium hydroxide (NaOH) is effective to pretreatment method of EFB fiber that reducing the content of residual oil, thus increasing the bonding in the EFB fiber structure. The elimination of oil residue increased the EFB fiber strength with the influence of existing of cellulose with is make the fiber ductile. The best proportion of tensile strength of single EFB fiber is 5% concentration with 3 hours soaking time. It reaches the maximum tensile strength is 0.5235 kN/m2. While for 1 hour soaking time is 3% concentration of sodium hydroxide.

Acknowledgement

This research was supported by Ministry of Education (MOE) through Fundamental Research Grant Scheme (FRGS K329). The authors would like also to thank Faculty of Civil Engineering and Build Environment, Universiti Tun Hessein Onn Malaysia for providing for its support.

References

[1] Harahap, et al., "Moderate Pretreatment Strategies for Improvement of Reducing Sugar Production from Oil Palm Empty Fruit Bunches," *In IOP Conference Series: Earth and Environmental Science*., *Vol. 443, No. 1, p. 012081*, 2020, February, doi: 10.1088/1755-1315/443/1/012081.

[2] Maynet, W., Samsudin, E. M., & Soh, N. N., "Physical and mechanical properties of cement board made from oil palm empty fruit bunch fibre: A review," *In IOP Conference Series: Materials Science and Engineering*., *Vol. 1144, No. 1, p. 012008*, 2021, May.

[3] Abas, N. H., Jaafar, A., & Mat Seman, A. S., "Some Basic Properties of Cement Board Produced by Using Oil Palm Empty Fruit Bunch (EFB *Penerbit UTHM. Article.1,77-87*, 2018, Retrieved from https://core.ac.uk/download/pdf/237206482.pdf

[4] Barlianti, V., Dahnum, D., Hendarsyah, H., & Abimanyu, H., "Effect of Physical, Chemical and Thermal Pretreatments on The Enzymatic Hydrolysis of Oil Palm Empty Fruit Bunch (OPEFB)," *J. Trop. Agric. Fd. Sc, 36(2), 259-268.,* 2015, Available from http://jtafs.mardi.gov.my/jtafs/36-2/Oil%20palm%20empty%20fruit%20bunch.pdf

[5] Jawaid, M., Saba, N., Alothman, O. Y., Khalil, H. A., & Mariatti, M., "Thermal Conductivity Behavior of Oil Palm/Jute Fibre-Reinforced Hybrid Composites,". *In AIP Conference Proceedings, AIP Publishing LLC*, *Vol. 1901, No. 1, p. 030007*, 2017, December, doi: https://doi.org/10.1063/1.5010472

[6] Mulyantara, L. T., Rizaluddin, A. T., Nakagawa-izumi, A., Ohi, H., & Nakamata, K, "). Properties of Fibers Prepared from Oil Palm Empty Fruit Bunch for Use as Corrugating Medium and Fiberboard," *Japan Tappi Journal, 69(12), 1349-1359*, 2017, Retrieved from https://doi.org/10.2524/jtappij.1508

[7] Hamzah, n. H. C., "Effect of Steam Pre-Treatment on Co-Composting of Oil Palm Empty Fruit Bunch,". Retrieved from http://psasir.upm.edu.my/id/eprint/70169/1/FK%202017%20106%20-%20IR.pdf

[8] Izani, M. N., Paridah, M. T., Nor, M. M., & Anwar, U. M. K., "Properties of medium-density fibreboard (MDF) made from treated empty fruit bunch of oil palm," *Journal of Tropical Forest Science, 175-183*, 2013.

[9] Hamzah, M. H., Deraman, R., & Saman, N. S. M, "Investigating the Effectiveness of Using Agricultural Wastes from Empty Fruit Bunch (EFB), Coconut Fibre (CF) and Sugarcane Baggasse (SB) to Produce Low Thermal Conductivity Clay Brick. *In AIP Conference Proceedings*, AIP Publishing LLC, *Vol. 1901, No. 1, p. 030005*, 2017, December, Retrieved from https://doi.org/10.1063/1.5010470