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Study on Water Resistant of Organic and Inorganic Fibre Panel Board

Khairul Hafizie Khairuddin[1], Muhammad Danish Hifzhan Amiruddin[1], Muhammad Izzat Zamri[1], Norhayati Ngadiman[1*]

[1]Department of Civil Engineering, Centre for Diploma Studies, Universiti Tun Hussein Onn Malaysia (UTHM), Pagoh, Muar, 84600, Malaysia

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Abstract :

Currently, with the environmental cautious, many studies show that the wooden panel board can be replaced with more environmental friendly materials such agriculture fibre and durable materials such as the fiberglass, coconut fibre, sugarcane bagasse and banana fibre. However, the different types of the panel board raw materials will occasionally contribute to the panel boards' water resistant which is vital because water resistant can affect the strength of the panel board. Therefore, this study aim to compare the water resistant of the varies fibre panel boards. In addition, this study investigated method to enhance the water resistance property of fibre panelboard by reviewing previous studies. The methodology of this studies is by testing water absorption and swelling test of different types fibre panel board which are fiberglass panel board, coconut fibre panel board, sugarcane bagasse panel board, banana fibre panel board. By reviewing through the 19 articles and journals using three stages process which is identification screening, eligibility and included to identify the method to increase water resistance of fibre panel board. Based on the results, the fiberglass has the highest density which is 1320 kg/m^3 and 0% of water absorption and swelling test. Meanwhile, the sugarcane bagasse has the lowest density which is $344kg/m^3$ and highest in water absorption and swelling test which is 108% and 3%. Thus, the finding indicate that higher values of density will provide better water resistance in panel board. In a nutshell, the fiberglass panel board is much better than the conventional wood panel board in terms of water resistant however, the fiberglass will be slight costly. In order to reduce the cost, the fibre panel boards can be layered with polyurethane coatings in order to enhance the water resistance properties of the fibre panelboard.

Keywords: Panel Board, Fiberglass Panel Board, Coconut Fiber Panelboard, Sugarcane Bagasse Panel Board, Banana Fiber Panel Board

**Corresponding author: nryati@uthm.edu.my*

1. Introduction

There are tonnes of timber was cut out in order to produce a panel boards that were used in the industry that was contribute to the current global warming and the destroy of the wild life habitats. Studies show that the conventional panel board can be replaced with fibre panel board. It is because the source of the fibre panel board is more eco-friendly and organic and inorganic fibre. Organic fibres grown naturally without the use of toxic and chemical substances such as persistent pesticides, synthetic fertilizers and genetic engineering. Meanwhile, inorganic fibres are materials that classified as man-made fibres which are made from chemical compound that will produce the final product in a form such as glass fibre and carbon fibre. There are four types of fibre panel board that best can replace the conventional wooden and environmental destruct panel board which are fiberglass panel board, coconut fibre panel board, sugarcane bagasse panel board, banana fibre panel board.

However, the different of materials to make the panel board will affect the water resistance of the panel board. Water resistant plays an important role as it can contribute to the strength of the panel board. The difference in materials will resulting in different water resistant due to the different materials properties. In order to solve this problem, this study aim is to compare the water resistant for each fibre panel board and also find a way to enhance the ready-made fibre panel board that are already in the market. The aim of this study are, (1) to compare water resistance properties of different types of fiber panel board, (2) to identify effect of panel board density toward water resistant properties of different fibre panel board, and (3) to identify the method to increase water resistance of fiber panel board

1.1 Coconut fibre

Coconut fibre is a natural fibre extracted from the outer husk of coconut [1]. There are two types of coconut fibre that be gained from coconut fruit. Brown fibre that harvested from form ripened coconuts. This fibre was thick, strong and has high abrasion resistance. It usually used in making mats, brushes and sacking. Mature brown coconut contain more lignin and less cellulose. Another type of coconut fibre is white coconut fibre that harvested from coconut before they are ripe. This white fibre was smooth and finer. This fibre usually used for making mats and rope. Past study research is done to determine the general length of natural coconut fibre for study purpose [2]. The coconut fibre shown in Figure 1 is used to make the coconut fibre panel board.

Figure 1: Coconut fibre

1.2 Sugarcane bagasse

Sugarcane bagasse is an abundant agro-industrial waste and the process extraction of sugarcane liquid into sugar will form these sugarcane bagasse [3]. Sugarcane is widely used in our economical industry such as produce sugar and sugarcane juice. This activity can boost our country economy however it also has the disadvantage which can cause industrial waste disposal. In order to overcome the problem of industrial waste disposal, the research on this sugarcane bagasse waste is needed because it can help to reduce the percentage of this waste that can be environmental problems [4]. The study research was conducted on three types of panel board and the sugarcane bagasse panel board has the lowest density and high water absorption [5]. Another research also obtained the highest water

absorption from the sugarcane bagasse panel board compared to conventional panel board [6]. By making sugarcane bagasse panel board, it can help to reduce the problem caused by the disposal of these materials. Sugarcane bagasse in Figure 2 obtained by extracting the liquid from the sugarcane.

Figure 2: Sugarcane bagasse fibre

1.3 Banana fibre

Banana fibre can be extracted from the pseudo-stem of banana plant that look like a trunk. This natural fiber has some advantages such as low density, appropriate stiffness and mechanical properties and high disposability and renewability. Moreover, they are recyclable and biodegradable [7]. Banana fiber also can be used in making some souvenir such as ropes, mats fabric and also handmade papers. Understanding the chemical composition and physical properties of the fibres is very important to utilize them properly [8]. Figure 3 shown banana fibre that be obtained from banana plant.

Figure 3: Dried banana fibre

1.4 Fiberglass

Figure 4 shows fiberglass chopped strand mat. This type of fiberglass used because the fibers are randomly arranged and compressed into a sheet (chopped strand mat) and woven into a fabric. The fiberglass is then bounded by any kind of binder. Because of its fabric character, it makes the fiberglass easy to be moulded into any shapes that required (in this case, chopped strand mat was moulded on top of the panel board and brushed with resin). This technic is also known as hand lay-up [9]. The pros of fiberglass are more flexible, more durable than any metals in terms of weight, non-magnetic and non-conductive. (“Guide to Glass Reinforced Plastic (fibreglass) [10].

Figure 4: Fiberglass chopped strand mat

2. Methodology

Figure 5 shown the research flow chart of this study. Based on the flowchart, selection of methodology according to the research objectives.. For the objective 1 and 2, in phase 1, organic fibre panel boards, the process is starting with estimating the density of the fibre, followed by weighting, spraying glue and hydraulic hot press machine. While the process of the manufacturing of the fiberglass panel boards are layering of the panel boards, cutting and finishing. In phase 2, the testing for the panel boards is divided into two types. Each of the panel boards will carry out two types of tests which are water absorption test and swelling test. In phase 3, all the result of the testing for each of the panel boards will be compared side by side in order to obtain the best panel boards with water resistant. Meanwhile, for the objective 3, the methodology for this review paper separated into three phases. First phase process is identification and screening process by using Google Scholar and ResearchGate as our database to find previous article using suitable keywords related to these materials which is coconut fiber, sugarcane bagasse, banana fiber and fiberglass. Second phase is the eligibility process which is each articles was reviewed thoroughly different from the first phase which only focused on selection criteria. The last phase is including the meta-analysis process which combining the results from the multiple primary research studies aimed at testing the same conceptual hypothesis and it also summaries in Table 1. Based on the Table 1, all the finding are about to enhance water resistant of the organic fibre panel board. There two journals are related to the combing method of the two different panel board. Other than that, the journals and articles are about to enhance the resistant of the panel board by adding waterproof layer on panel board.

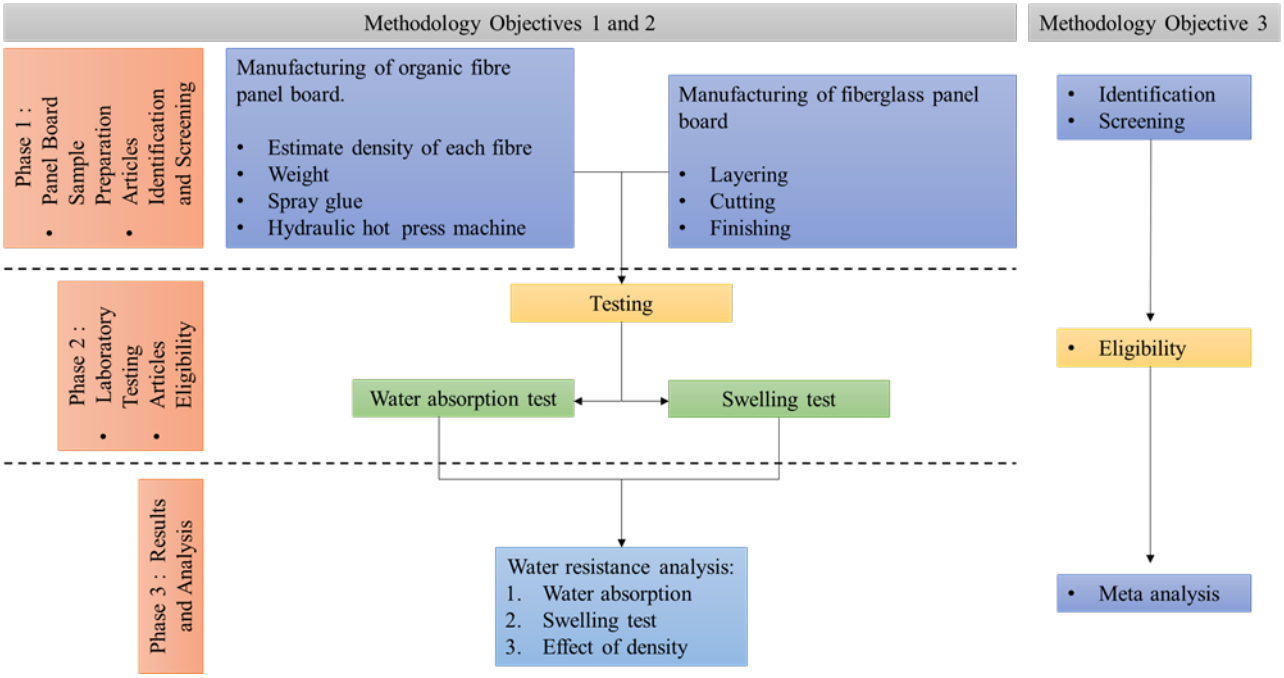

Figure 5: Flowchart of the project

Table 1: List of Journals from Meta-Analysis

Database	Keywords	Year	Number of articles
Google scholar	Organic fiber + fiberglass filler	2020	1
	Fiberglass panel board	2018	1
	Overlayed + timber	2010	1
	Polyurethane + coatings + high performance	2007	1
Science direct	Lacquer + coating	2019	1
	Polyurathane	2020	1
ResearchGate	Polyurethane + resin	2007 – 2017	3
	Waterproof + panel board	2017	1
	Wood coating + vanish	2015	1
	Laminated + timber	2010	1
	Coating + polyurethane	2017	1

	Lacquer + coating for wood	2018	1
	Wood + water resistant	2014	1
	Durable + wood protection	2017	1
US Department	Lacquer + coating for wood	2014	1
Technical data sheet	Wood + lacquer	2016	1
BBC.co.uk	Combining method + timber	2021	1

2.1 Fiberglass panel board process.

Fiberglass matt was cut out into the size of pile mould which is 600mm x 300mm. Then, resin and hardener were mixed well. After that, apply wax on the mould to prevent the fiberglass to stick to the mould. Next, fiberglass was laid on the waxed mould. Pour down the mixture of the resin and spread it through the surface of the fiberglass with brush. Let the fiberglass dried and then the fiberglass was cut into the sample size. Figure 6 show the sample of fibreglass panel board.

Figure 6: Fibreglass panel board

2.2 Coconut fibre panel board process.

Coconut fibres were sieved using sieve machine. After that, coconut fibres were weighed using a balance and then mixed well with urea glue according to 7:3 ratio in a mould. Mixed coconut fibres were compacted with hot press hydraulic machine at 170 degrees Celsius**.** Figure 7 shows panel board from coconut fibre panel. Next, the panel board was cut into a sample size.

Figure 7: Coconut fibre panel board

2.3 Sugarcane fibre panel board process.

Sugarcane bagasse was dried under the sun for 7 to 8 hours. Then, this sugarcane bagasse was grinded become fibres and all those fibres were dried in the oven. After that, the fibres were sieved to get the small size. Those fibres need to weigh using a balance and mixed with urea glue with 7:3 ratio in a mould. After that, the mixed fibres were compacted with hot hydraulic press machine. The panel board was cut into the sample size like Figure 8.

Figure 8: Sugarcane fibre panel board

2.4 Banana fibre panel board process.

Banana fibres were obtained by slicing and shredding the banana stem. Then, the fibres were dried at 80 degrees Celsius and weighed using a balance. After that, the fibres were mixed with the urea glue with ration 7:3. The fibres were put into the mould than were compacted with hot hydraulic press machine at 170 degrees Celsius. Figure 9 shows sample of banan fibre panel board after the hydraulic press. Then, the panel board was cut into the sample size.

Figure 9: Banana fibre panel board

2.5 Testing method

Water absorption test is about to test the resistance of panel board to water after immersed in water for 24 hours. Container with appropriate size and a digital weight have been used as instrument for this test. Eq. 1 is used to determine water absorption.

$$\frac{W-Wd}{Wd} X\ 100\%$$

Eq.1

W = weight of sample after immersed in the water.

Wd = weight of sample before immersed.

Next test is sweeling thickness test. This test is about to determine the expanded size of each sample panel board after being immersed for a certain time. Sample from each design will make a thick comparison. The panel board has more thick increase will be considered low resistance to water and has high water absorption**.** Figure 10 show the condition of sample panel board immerged in water for 24 hours.

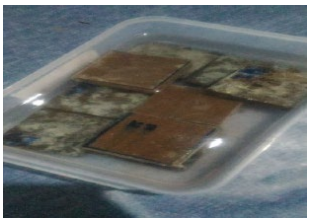

Figure 10: Immerged fibre panel boards

3. Results and Discussion

3.1 Water absorption

Table 2 shows the result of water absorption for fiberglass panel board, coconut fibre panel board, sugarcan bagasse panel board and banana fibre panel board. These panel board compared with wood panel board in term of density and water absorption. Figure 11 shows the relationship between density and water water absorption of the panel board. The fiberglass panel board has the highest density. Three organic fibre panel board which is coconut fibre, banana fibre and sugarcan bagasse have the lower density compare to wood panel board which are $700kg/m^3$, $629kg/m^3$ and $344kg/m^3$. The wood panel board has 1000 kg/m^3 in density. In term of water absorption, fiberglass got the lowest which is 0% and completely can resist water. Meanwhile, wood panel board has 49.6% of water absorption and lower than three types of organic fibre. Coconut fibre panel board has 78.1% water absorption followed by banana fibre 100% and the highest water absorption is sugarcane bagasse which is 108% of water absorption. Organic fibre panel board such as banana fibre and sugarcane are likely to absorb more water as those organic fibres are containing a considerable amount of parenchyma cells. This type of cell was hygroscopic which able to absorb more water [11]. Meanwhile, fibreglass is non-organic fibre and not containing any hygroscopic cell make this completely high-water resistant. Sugarcane bagasse has the highest water absorption because it has low density compare to banana fibre [12]. Coconut fibre absorb less water compared to most other natural fibers due to their lower composition of cellulose content compare to other organic fibres [13]. From this analysis, density of the panel board also give a impact in water absorption of the panel board. The highest value of density will produce the lowest water absorption. In other words, high density can increase the water resistant of the panel board.

Table 2: Density and Water Absorption of Fibre and Wood Panel Board.

Panel Board	Density(kg/m^3)	Water Absorption(%)
Fiberglass	1320	0
Coconut Fibre	700	78.06
Sugarcane Bagasse	344	108
Banana Fibre	629	100
Wood	1000	49.6

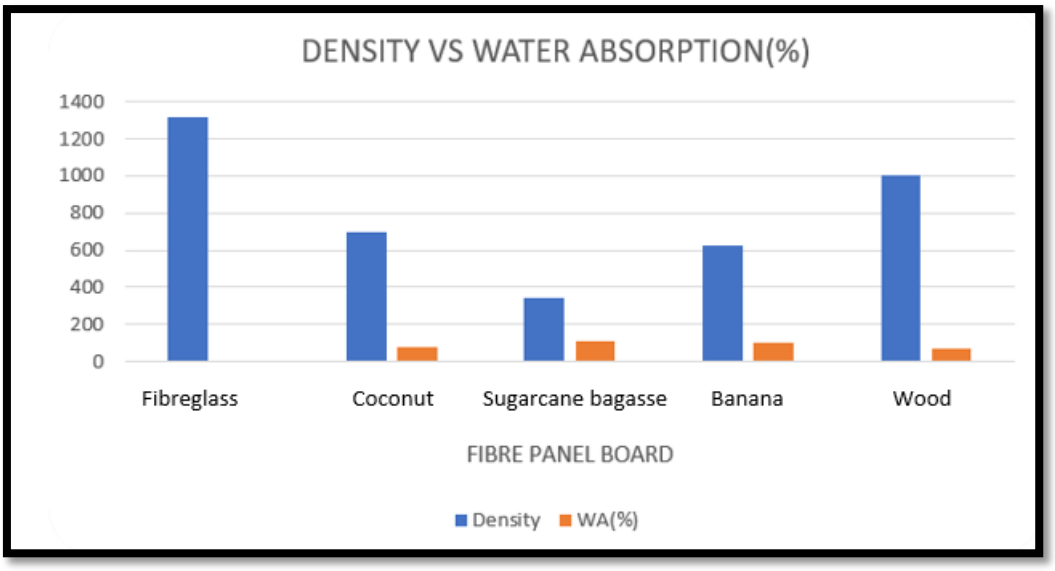

Figure 11: Graph Bar of Panel Boards Density and Water Absorption Percentage

3.2 Thickness swelling

Table 3 shows the result of thickness swelling for fiberglass panel board, coconut fibre panel board, sugarcan bagasse panel board and banana fibre panel board. These panel board compared with wood panel board in term of density and thickness swelling. Based on Figure 12 shows about the relationship between density and thickness swelling of the panel board. The represent data show that the fiberglass has the highest value of the density which is $1320kg/m^3$, then followed by wood panel board, coconut fibre, banana fibre and sugarcane bagasse fibre. The density value for wood panel board, coconut fibre, banana fibre and sugarcane bagasse are $1000kg/m^3$, $700kg/m^3$, $629kg/m^3$ and $344kg/m^3$. In term of thickness swelling, banana fibre panel board has the highest value of thickness swelling which is about 17% while the fiberglass panel board and coconut fibre panel board has the lowest value of thickness swelling which is 0%. The value of thickness swelling for sugarcane bagasse fibre panel board is about 3% and followed by the wood panel board which is about 3%. The density of the panel board plays a role in thickness swelling of the panel board. If the panel board has the high value of density it considered the panel board has a low value of thickness swelling [14][15]. The coir fiber known as one of the most lignin-rich natural fibres which can control the swelling effect [16]. Materials that have more porosity can easily allow more water intake to be absorb [17]. High density cause low amount of porosity in the panel board which can lower the rate of water absorption to avoid from panel board be swell when immersed in water. This analysis can conclude that high density of the panel board will decreases the tendency of panel board to become swell when exposed in water. Therefore, the lowest density of the panel board considered to get highest amount of thickness swelling.

Table 3: Density and Thickness Swelling of Fibre and Wood Panel Board.

Panel Board	Density(kg/m^3)	Thickness Swelling(%)
Fiberglass	1320	0
Coconut Fibre	700	0
Sugarcane Bagasse	344	3.3
Banana Fibre	629	17.1
Wood	1000	2.8

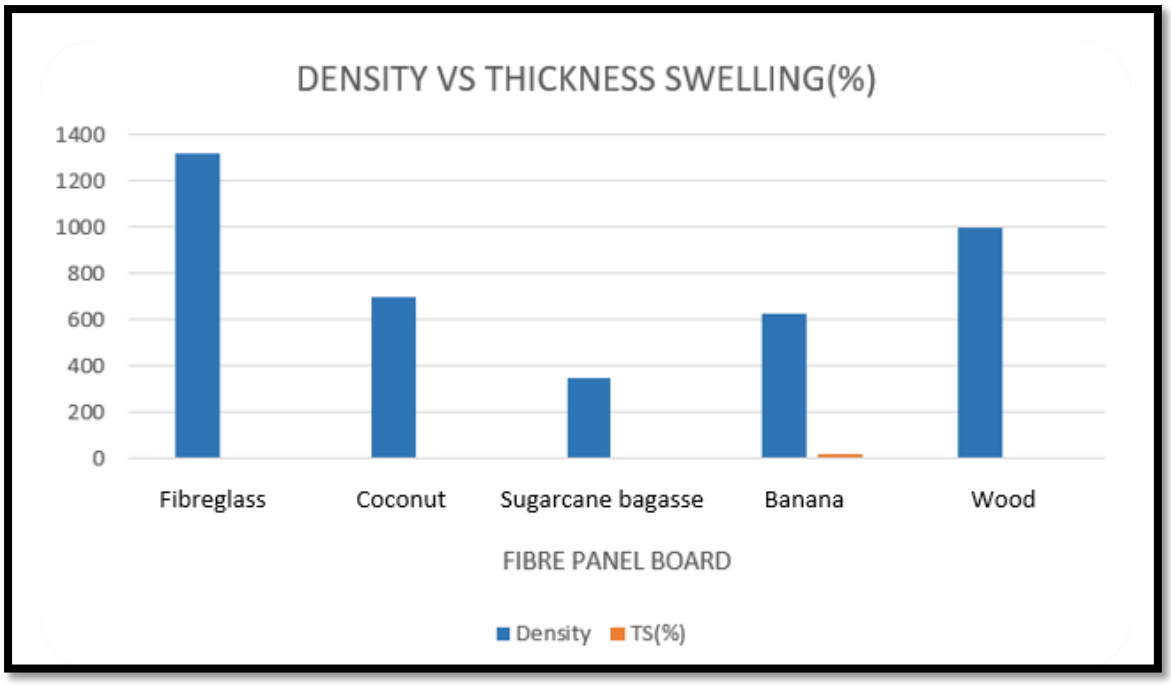

Figure 12: Graph Bar of Panel Boards Density and Water Absorption Percentage

3.3 Method to increase water resistant of the fibre panel board.

By reviewing 19 articles and journals according to three phases which are identification screening process by using Google Scholar and ResearchGate as our main database range from 2005 to 2021 to find any related article using the suitable keywords related to these materials which is coconut fibre, sugarcane bagasse, banana fibre and fiberglass. Second phase is the eligibility process which is each articles was viewed thoroughly to find the methods to increase the water resistant of the fibre panel board. The last phase is the process including the meta-analysis process which combining the findings from the primary research studies. As the results, there are two methods to increase the water resistant of the fibre panel board.

3.3.1 Combination method.

The method to increase water resistant can be done by combining two different fibre board. This combination can be design by using the fibreglass as outer layer for each fibre panel board [18]. The fibreglass as outer layer can increase the water resistant of the panel board and also termite attack [18]. Other than that, fibreglass also reacts as reinforcement for the panel board as it has high Modulus of Rupture (MOR) and Modulus of Elasticity (MOE) which make this combination more durable than standard panel board [18].

3.3.2 Coatings

Using Polyurethane or laqcuer to layering the fibre board surface also can increase the water resistant. Polyurethane is mainly used on MDF panel board which has low percentage of water resistant [19]. Therefore, using polyurethane or lacquer on fibre panel board slightly can increase water resistant property. Applying this plastic material also can decrease the thickness swelling of the panel board [19]. Once polyurethane applied on the fibre panel board, panel board no longer can absorb water as it porosity has been cover with polyurethane coating layer [20].

4. Conclusion

In conclusion, the fiberglass panel board has the best water resistance among the other fiber panelboard in terms of density and water absorption. However, the fiberglass panel board will be costly compared to organic fibre. Therefore, based of review previous studies, the suitable method to increase the water resistant of the fibre panel board is using the coatings method with polyurethane or lacquer compared to the combination method which has complicated procedures. Polyurethane also shows the same pattern in thickness swelling test which is have the lowest percentage of thickness swelling among the other coating layer. Polyurethane that being applied on the surface of the fibre panel board does not cause harm or affect the characteristic of the fibre but polyurethane manage to prevent from water absorption. If the surface of fibre panel board have been layered, it is no longer can absorb water because the porosity of the fibre have been cover with polyurethane coating layer.

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