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The Use of Areca Nut Fiber in Soundproof Particle Board Manufacturing

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Abstract : The particle board that is now used in Malaysia has drawbacks in a number of ways, including the high cost of production. Areca is one type of plant which has many used. The seed and stem have been utilized while the shell coin only becomes organic waste. Currently, the use of organic waste such as coir is gaining attention in the manufacture of particle board. The aim of this project is to insvestigate the physical and mechanical properties of particel board form areca fiber as a soundproof panel. The urea-formaldehyde glue and hardener will be combined during the production of this particle board made from areca fiber. Studies show that areca has the potential to be utilized in particle board construction since natural fiber is an excellent sound absorber. This research will take place in UTHM Pagoh's laboratory. Particle boards with thickness of 5mm and 10mm with size of 300mm x 300mm have been fabricated going through mechanical and physical tests. Mechanical tests like the MOR test and the water absorption test are produced. The MOR values found were 6.75 mg/mm^2 and 2.81mg/mm^2. As a sound absorbing particle board, through the sound absorption test it is found that the transmission loss value is 10.3dB and 15.4dB. Lastly, particle board with size 5 mm and 10 mm from areca fiber can be used as a soundproof panel in the construction industry.

Keywords: High Cost, Areca Fiber, Particle Board, Absorption, Soundproof.

1. Introduction

The human sense of hearing, primarily the ear, may detect sound as one of several types of waves. Noise is classed as pollution because it interferes with human existence when the echo of the sound generated is excessively loud. Sound-absorbing materials, according to some study, can lessen echo levels, especially in confined areas or rooms. As a result, based on the findings of earlier investigations, a study of betel nut as a sound-absorbing material will be done and investigated. The areca is a natural fiber material with several applications in human existence [1].

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The people used to consume areca nuts and betel together. The fiber will be incinerated after being tossed away. This might lead to a rise in carbon dioxide levels, polluting the environment, particularly the air. Areca fiber can be utilised as one of the materials in building to avoid this from happening [2] & [3]. This is due to the fact that its application in the building sector is currently limited. The objective of this project are to find out the factors that affect particle board, to form particle boards from areca fibres and also to evaluate the strength and soundproofing of the resulting particle board. This research are using the Japanese Index Standard, JIS A 5908 2003 as a reference. Based on previous studies they only use JIS reference because it is more clear in the production of particle board than natural fiber.This research will take place in UTHM Pagoh's laboratory.

2. Materials and Methods

2.1 Fabrication of particle board

Two moulds in a rectangular shape with different thicknesses were made. The moulds were produced in the size of 3000mm x 3000mm. The thickness of the moulds are 5mm and 10mm. For the raw material processing, the areca fibres are soaked in Natrium Hydroxide (NaOH) solution for 2 hours and rinsed with warm water before being dried under the sun for three days [4]. Next, the areca fiber is mixed with gam Urea Formaldehyde (UF) and hardener. The mixer was then put in two types of mould with the size of 300mm x 300mm x 5mm and 300mm x 300mm x 10mm. The mould with the mixer was placed in the hot press machine with a pressure of 180 Pa at a temperature of 150°C for 8 minutes. This process shows in **Figure 1.**

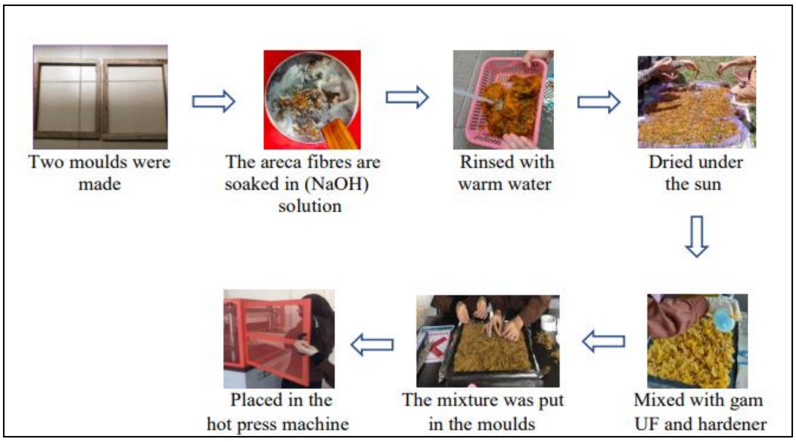

Figure 1: Fabrication of Particle Board

2.2 Testing

Several tests have been selected to test the level of strength and durability of particle board by producing a compressive strength test (MOR) and also a water absorption rate test. In addition, a soundproofing test was also selected to test the ability of particle board to absorb sound. This test is chosen to ensure that the particle board produced is of good quality and soundproofing.

2.2.1 Water absorption rate test

This test is to show the ability of particle board to absorb water after immersion as shown in **Figure 2.** The mass of the particle board will be weighed three times for each specified period of time in a dry state, after being soaked for 24 hours and 48 hours. The data obtained will be converted to percentages using the water absorption formula and subsequently will be translated into the form of graphs.

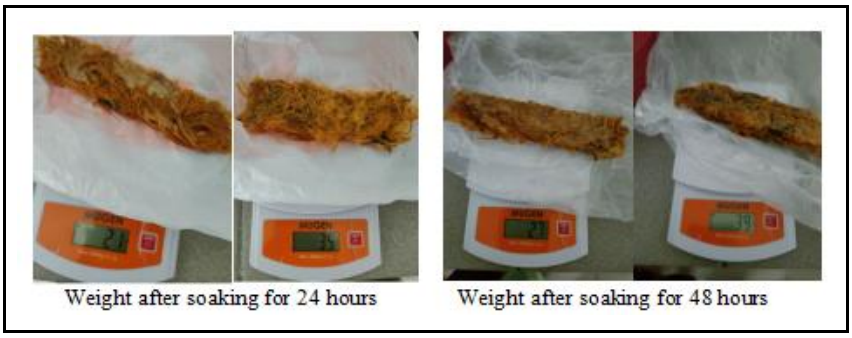

Figure 2: Water absorption weight

2.2.2 Modulus of Rupture (MOR)

Test the strength level of particle board from the areca fiber as shown in **Figure 3.** Particle board samples measuring 300mm x 20mm x 5mm were used for testing. A particle board sample will be placed on a support and then a load will be placed on top and in the middle of the sample until it reaches the failure level. This process will be repeated using a sample size of 300mm x 20mm x 10mm and all data will be recorded. The data will be calculated using the MOR formula before being converted into graph form.

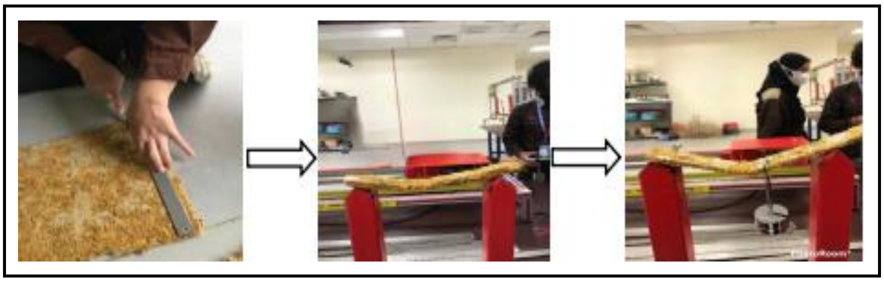

Figure 3: Modulus of rupture test

2.2.3 Soundproofing test

This test aims to determine the potential of particle board from areca fiber as a sound -absorbing material. The set up for the test is as shown in **Figure 4**. 5mm and 10mm thick particle boards were used and cut according to the size of the test box. A noise level metre is used to measure the noise intensity inside and outside the test box, which has been covered with particle board samples. The amount obtained will be recorded as a transmission-loss value and plotted in a graph.

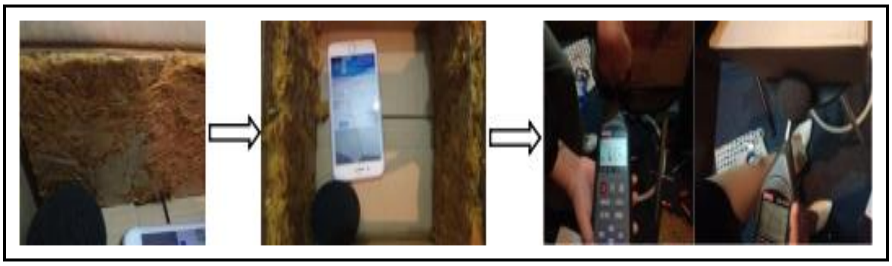

Figure 4: Soundproofing test

3. Results and Discussion

3.1 Water absorption rate data

The purpose of performing this test is to test the amount of water content that can be absorbed by the resulting particle board. This water absorption rate is done to prove the quality of particle board. **Table 1** shows the percentage of particle board water absorption (**Eq.1**).

$$Water\ Absorption\ \% = \frac{WB - WA}{WA} \times 100\% \qquad \textbf{Eq. 1}$$

WA = Initial weight of the test sample (kg)

WB = Weight of the test sample after immersion (kg)

Table 1: Water absorption percentage

Thickness (cm)	After 24 hours (%)	After 48 hours (%)
5	200.0	285.7
10	191.7	225.0

Based on the **Table 1**, 5 cm thick particle board has a high water absorption percentage of 200.0% compared to 10 cm thick particle board, which has a water absorption percentage of 191.7% after soaking for 24 hours. While the 5 cm thick particle board soaked after 48 hours, it also got the highest water absorption percentage value of 285.7% and the lowest on the 10 cm thick particle board with a value of 225.0%. Several factors have been identified from the total percentage of water absorbed by the particle board at each thickness.

Figure 5 shows the particle board samples were soaked for 24 hours and obtained the highest water absorption value in a 5 mm thick sample. Next, samples soaked for 48 hours also obtained the highest water absorption values on 5 mm thick particle board samples. Based on the results of the study, the value of water absorption obtained is between 191.7% and 285.7%, which is close to the results of a study conducted by [5], who got the value of water absorption between 125.93% and 182.87%. According to [6] Standard JIS A 5908-2003, it does not set a value for water absorption and these experiments are still carried out for the purpose of determining the resistance of particle board to water. The results of the experiments conducted for 24 hours and 48 hours showed that the value of water absorption has various values where the highest value is found in samples with a thickness of 5 mm and the lowest in samples with a thickness of 10 mm.

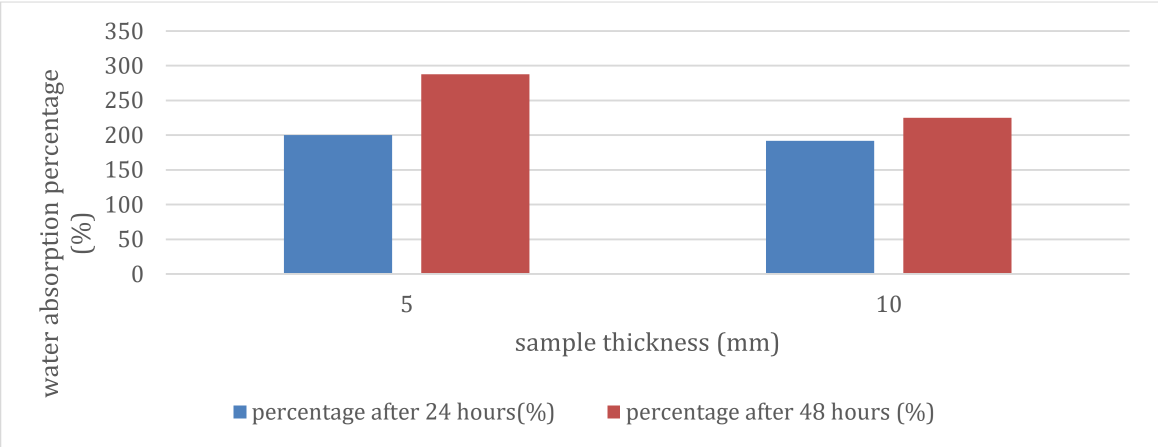

Figure 5: Graph water absorption percentage (%) vs thickness (mm)

3.2. Modulus of Rupture (MOR)

This test is performed to obtain the strength of the particle board sample. JIS A 5908 2003 served as the basis for conducting this test. The MOR value obtained is from the calculation made using the formula $MOR = \frac{3PL}{2bh^2}$. Where,

P = load (mg), L = distance between support (mm), b = sample width (mm), h = sample thickness (mm)

Table 2: The value modulus of rupture (MOR)

No.	Type of support	Load position	Thickness, (mm)	Load (mg)	MOR value (mg/mm^2)
1	Fixed	center	5	50	2.25
				100	4.50
				150	6.75
2	Fixed	center	10	50	0.56
				100	1.13
				150	1.69
				200	2.25
				250	2.81

Table 2, shows the value modulus of rupture (MOR). Based on the data obtained, the loads applied to samples of 5 mm thick particle board were 50 mg, 100 mg, and 150 mg, with respective MOR values of 2.25 mg/mm^2, 4.50 mg/mm^2, and 6.75 mg/mm^2.Beside that, the loads applied to samples with a thickness of 10 mm are 50 mg, 100 mg, 150 mg, 200 mg, and 250 mg, with MOR values of 0.56 mg/mm^2, 1.13 mg/mm^2, 1.69 mg/mm^2, 2.25 mg/mm^2, and 2.81 mg/mm^2.

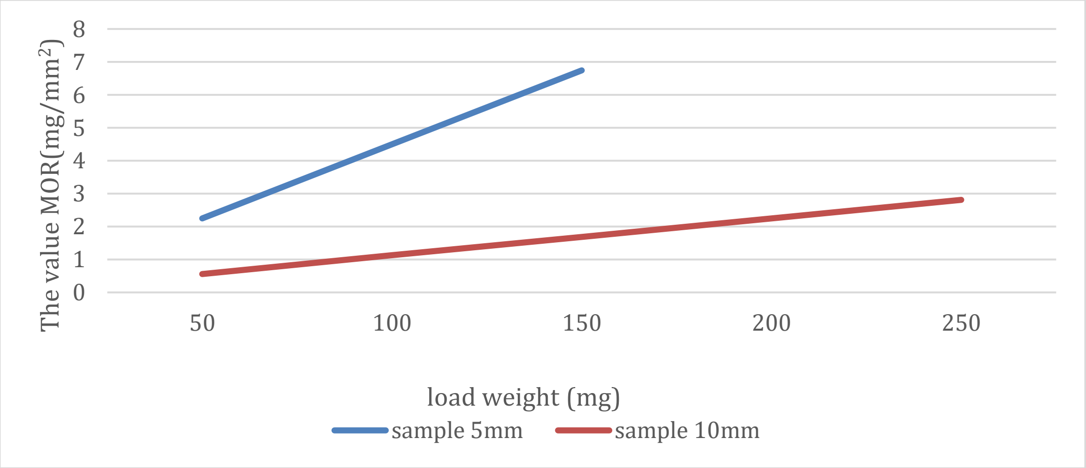

Figure 6: Graph the value MOR vs load weight

The graph, which is based on **Figure 6**, reveals that the particle board sample with a thickness of 5 mm has the highest MOR value, 6.75 mg/mm2. The MOR value for particle board samples with a 10 mm thickness, however, can reach 2.81 mg/mm2. This demonstrates that samples with a thickness of 5 mm can only support 150 mg of load, but samples with a thickness of 10 mm can support up to 250 mg of force before failing. As a result, the load that can support the sample to reach the degree of failure increases with the thickness of the particle board sample. The MOR value is still below the JIS A5908 2003 MOR value, which must be higher than 82 kg/cm2 [6]. This is due to the cut particle board sample being too tiny during the test run. The sample's preparation also has an impact since insufficient glue used to construct the particle board may result in a weaker and more fragile sample. To reach the MOR value of JIS A 5908 2003 [7], accurate sample and cut preparation is required.

3.3 Soundproofing test

The soundingproofing test result is represented in **Table 3**. **Table 3** shows that the time for each reading taken was the same which is 20 seconds. The test was conducted in three conditions. The first condition was when the box without any particle board (0 mm), when a 5 mm thick particle board was placed in the test box, and when a 10 mm thick particle board was placed in the test box. Readings were taken using a sound level meter placed inside and outside the test box. Reading inside and outside was subtracted to obtain the transmission loss for each condition. The total transmission loss for the empty box was 3.2 dB, 10.3 dB for 5 mm thick particle board, and 15.4 dB for 10 mm thick particle board.

Table 3: Table of Soundproofing Test

	Condition	Time (second)	Value Inside (dB)	Value Outside (dB)	Transmission Loss (dB)
1	Empty Box, 0 mm	20	60.2	57.0	3.2
2	Particle Baord ,5 mm	20	61.4	51.1	10.3
3	Particle Board, 10 mm	20	63.4	48.0	15.4

Based on the **Figure 7 and Figure 8**, the significant differences in the readings inside and outside the test box can be seen on a 10 mm thick particle board of 15.4 dB. The second is the difference for the 5 mm thick particle board readings and the smallest reading difference is on the blank box (0 mm). This indicates that a 10 mm thick particle board can absorb more sound than a 5 mm thick particle board when the box is empty (0 mm). The higher the total transmission loss, the better the sound absorption rate of the particle board. On the transmission loss graph, the reading for transmission loss increases if the particle board thickness increases. This is because the thickness of the particle board influences the rate of sound diffusion. The thicker the particle board, the more sound it can absorb. According to Sound Transmission Class, test method E90 was used to calculate the transmission loss as above [8].

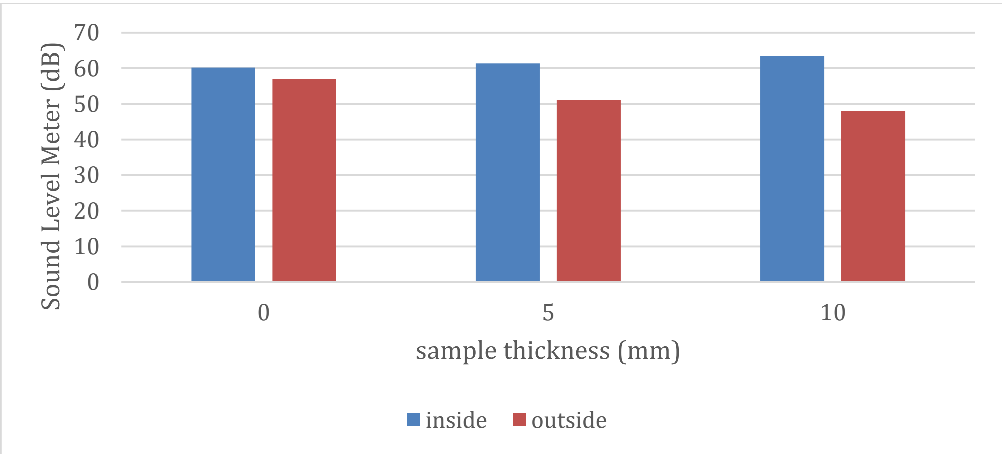

Figure 7: Graph Sound Level Meter (dB) with Thickness (mm)

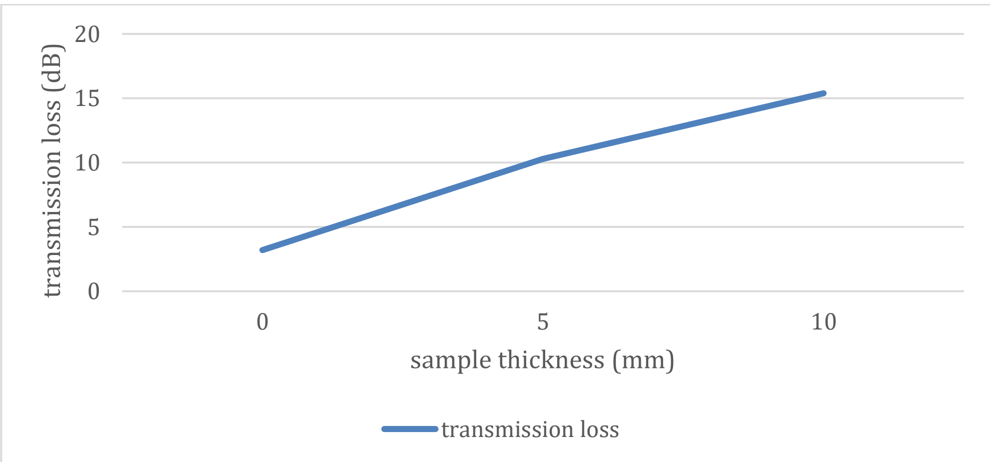

Figure 8: Graph Transmisson Loss (dB) with Sample Thickness (mm)

4. Conclusion

In conclusion, we can understand the characteristics of particle board from the description already mentioned above. The objectives of this study have been achieved. Particle board from areca fiber has been successfully produced. The main test for this study was soundproofing test. The result of the test showed that the particle board from the areca fiber produced showed satisfactory result. The data obtained also show that areca fiber can be used as the main material in the manufacture of good soundproof particle boards. Tests such as water absorption test and compressive strength test also were performed to test the strength of the particle board. The result have shown that the tests does not reach the standard set by JIS 5908-2003. Both of these test were done only as a supported test for the particle board. The production of this project can also prove that areca fiber can be used in the production of a good soundproofing particle boards.

There are several suggestions for improvement that can be made in the future for the production of soundproofing particle boards. Particle board can be produced by using two types of fiber such as a mixture of coconut fiber and areca fiber. Other than that, the areca fiber can be combined with tapioca adhesive. Optimizing the concentration of a mixture of particles and adhesives used to obtain the characteristics of newly developed materials.

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