The Application of Coconut Fiber as Insulation Ceiling Board in Building Construction

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Abstract. This study considers the applications of natural fiber composites in affordable housing projects located in Malaysia with the goal of addressing issues of the thermal comfort. Roof thermal insulation is one of the effective methods that can save cooling energy in places with an equatorial climate especially in Malaysia. The use of recycled products or industrial waste materials is now a potential trend in the industry. Therefore, natural fiber was chosen as a material for the ceiling board in this study. During the day, heat can enter the room from the roof so that insulation material is needed to reduce heat flux by maintaining the temperature of the building. The problems faced by consumers are cost increases due to the use of large amounts of electricity. Besides, asbestos use becoming less frequent because the government has banned its use as a ceiling, side panels, roofing material, asbestos cement-pipes, many types of fireproof and insulation material. The objectives of this study was to determine the mechanical and physical properties of coconut fiber with fire retardant paint as a thermal comfort for ceiling board. The next objective is to study the percentage difference in sodium hydroxide and sodium chloride during the treatment of coconut fiber. The data result is that the fiber is ideal as an insulating material for the house ceiling board because it has a low temperature quality of 0.225W. The water absorption value was as high as 11.20% which is slightly lower than previous studies. Finally, the density test has a value of 74.23 kg / m3 where the fibers are lighter than the other fibers even after immersion with different sodium hydroxide and sodium chloride. In addition, this study achieved a house ceiling that could help reduce the heat entering the house by 0.225W which used only a thickness of 10mm. The use of these fibers does not need the thickness between 20 mm or 40 mm. Therefore, it successfully lowered home electricity consumption in hot weather. It was found that the difference in temperature drop between 0 % and 3 % was 0.4W.

1. Introduction
Malaysia's extreme weather events are described by days of elevated temperature, elevated rainfall, dry spell, thunderstorm, and powerful winds. Malaysia is hot and humid all year round, interspersed with the year's tropical rain shows. This climate is experienced by areas located on or near the equator line. The most important climate effect in Malaysia's buildings is high solar radiation intensity and high daily air temperatures [4-7]. Due to solar radiation, thermal gain through the roof can be achieve up to 1 kW / m2 during clear sky circumstances and 20% to 95% of this radiation is usually absorbed by roof surface [8].
The use of recycled materials from products or industrial waste has become a future trend in the manufacturing industry, according to the protection of the environment and the conservation of natural resources. As stated in the FFTC Policy Platform for Agriculture (FFTC-AP) Malaysia remains one of the top 10 coconut producers in the world after oil palm, rubber and rice, coconut is the fourth major industrial crop in Malaysia. Coconut is also a natural ingredient and does not pollute the environment, so it is one of the material was selected in this study. The Natural fiber is a flammable material and must therefore be strengthened with fire-retardant paint.

2. Materials and methods

2.1. Process of Materials
In this process stage, all samples were treated with chemicals substance. The CF was easy to tear apart when lifting because of it easy to absorb water. Therefore, a suitable container was used to avoid the samples from tear apart. The use of 100% CF as material the ceiling is based on the advantages of CF that is suitable for thermal insulation and does not pollute the environment as well as the material to be recycled. The CF was cut in accordance to the dimension of 150mm x 150mm x 10mm. Then it was reinforced with FRP that can provide fire protection and reduce fire spread.

2.2. Thermal Conductivity Testing
The test was carried out by vertically mounting the block samples to form a small wall to match the opening of the 500 mm x 500 mm hot box chamber between the hot and cold chambers. Therefore, to obtain thermal conductivity value should use the equation (1).

\[ \frac{H}{t} = \frac{\lambda A (\theta_s - \theta_c)}{d} \]  

(1)

2.3 Water Absorption
The water absorption test was performed to assess the water absorption rate to be absorbed by the sample. The method used complies with standards MS 147: (2001) or ASTM D 1037-8. The equation for calculating the water absorption rate as shown in equation (2).

\[ M\% = \frac{(W_w - W_s) - (W_d - W_s)}{(W_w - W_s)} \]  

(2)

Water absorption tests required a relatively high temperature of between 100°C and 110°C for 24 hours. The procedure for water absorption was all sample was soaked in water at room temperature about 24 hours. The next step was removed the sample and sample mass reading was recorded (Obam, 2012). The sample was placed in the oven for 24 hours at a temperature between 100°C and 110°C. After that, the sample was cooled at room temperature. Finally, the sample was weighed and the weight recorded after removal from the oven.

2.4 Density
The sample was soaked in distilled water for 24 hours and then dried for 24 hours. After that, the sample was weighed again by using a weighing machine. The density readings of the samples in distilled water were recorded. Density (\(\rho\)) was a mass of samples over volume which in kilograms per meter cube. Equation (3) was used as formulas in this research.

\[ \rho = \frac{m}{V} \]  

(3)
This test was performed by following the procedure density test. The machine was turned on and the specimen was put on the weighing machine to get the weight of the sample. The sample was soaked in distilled water for 24 hours and then dried for 24 hours. After that, the sample was weighed again by using weighing machine. The density readings of the samples in distilled water were recorded.

3. Materials and methods

3.1. Thermal Conductivity

Figure 1 shows rate of heat flow between the faces (w) which is 3% has lower rate rather than other samples which are 0.225W. That means thermal conductivity of samples can reduce heat flow into the chamber. The sample has to be of low rate of heat to obtain a good heat value [1].

![THERMAL CONDUCTIVITY CHART](image)

Figure 1. Rate of Heat Flow (W) with the Different Percentages of NaOH and NaCl

3.2. Water Absorption

As seen in figure 2, the percentage of water absorption where 0% and 3% have less value than the other. Then, a 1% sample has the highest absorption meaning that a lot of water has been absorbed by the sample. If the fiber absorbs a lot of water, the ceiling material should not be applied as the ceiling board [3].
3.3. **Density**

Figure 3 shows the percentages of 1% for samples A, B and C has a lower density value which 70.67 kg/m³, 77.34 kg/m³ and 74.67 kg/m³. While, the percentage of 0% have the highest density for sample A, B and C which 99.56 kg/m³, 95.11 kg/m³ and 107.11 kg/m³. Therefore, the sample was slightly heavier than other samples. The percentages of 0% and 3% have a higher value of density. Heavy samples can result in the sample dropping or failing to withstand the load. The sample must be of low density to obtain a good heat value [3]. This can be described that the thermal conductivity depends on the density from [2] in which the thermal conductivity value decreases as coconut fiber density increases due to the effect of NaOH and NaCl percentages.

![Figure 2. Percentages of Water Absorption](image)

![Figure 3. Chloride profile of sample Id, Half 1 – with and without filter](image)
4. Conclusions
It can be concluded that the CF’s main weakness was that it’s easy to decay and the problem was solved. Because of that to ensure that the CF did not decay, treatment process was carried out on the fibers. It has been identified as the weakness of the samples to produce this material. The CF were immersed in 4%, 3%, 2%, 1% and 0% of NaOH and 96%, 97%, 98%, 99% and 100% of distilled water in polypropylene container within 24 hours to exchange cellulose. In addition, 4% 3% 2% 1% and 0% of NaCl were mixed with 96%, 97%, 98% 99% and 100% of methanol to activate OH groups on cellulose and lignin fiber.

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