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Ceiling Board Development Using Bamboo and Polypropylene as An Alternative to The Ceiling

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Abstract: As overcome this bamboo waste issue, local bamboo should be used in a variety of ways, such as converting bamboo waste into ceiling board panels and polypropylene as a green and sustainable product. To develop and test an eco-ceiling board made from bamboo waste and polypropylene. This study focuses on the production of bamboo ceilings with high durability and strength requirements, as well as excellent sound absorption. The polypropylene 90.00 % was 144 grams, bamboo powder 6.00 % was 9.6 grams and resin carbon 4.00 % was 6.4 grams as Sample 1. Polypropylene 80.00 % was 128 grams, bamboo powder 12.00 % was 19.2 grams and resin carbon 8.00 % was 12.8 grams as Sample 2. Polypropylene 70.00 % was 112 grams, bamboo powder 18.00 % was 28.8 grams and resin carbon 12.00 % was 19.2 grams as Sample 3 and lastly, Polypropylene 70.00 % was 112 grams and bamboo powder 30.00 % was 48 grams as Control sample. The tensile strength of Sample 3 was 58.2 MPa was optimum values. Thus, the Young's Modulus of Sample 2 was 16.75 GPa was optimum values. The water absorption of sample was 1.12 % for optimum value for control sample. The optimum value for thermal conductivity of the sample 1 was 0.0112 k W/m^{o}C. Besides that, the optimum value for thermal resistance was the sample 2 was 4.358 R^{th} ^{o}C/W. The optimum value sample for the sound absorption coefficient continuous of sample 3 was chosen.

Keywords: Ceiling Board, Bamboo Powder, Polypropylene

1. Introduction

The materials employed determine the effective performance of building ceilings. As a result, some of the ceiling's functions, such as aesthetics, acoustic control, durability, fire resistance, heat insulation, and access to the pressurised chamber. Ceilings are commonly made of asbestos, wood, polyvinyl chloride (PVC), and plaster of Paris (POP). [1]

Bamboo fiber is the main basic raw material for this research work. Bamboo has been dubbed the "21st Century Wood" by Thi Bich Vân (2018). Bamboo's adaptability makes it an excellent choice for flooring, roofs, concrete reinforcement, scaffolding, pipes, and walls. [2]

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Asbestos ceilings are widely used in most buildings such as houses, and other construction material. There is very fine carcinogenic dust on the asbestos ceiling, which has been falling and flying in the air. Asbestos dust can cause cancer, also called mesothelioma. Currently, the Malaysian government discourages the use of asbestos ceilings.

This research focuses on the manufacturing of bamboo ceilings with high durability and strength requirements, as well as good sound absorption as according to American Society for Testing and Material (ASTM). Eco-ceiling boards are made from bamboo waste and polypropylene. Water absorption tests, sound absorption tests, tensile tests, and thermal conductivity testing are performed on each ceiling board sample.

2. Materials and Methods

2.1 Materials

• Bamboo powder

The bamboo powder used in this study was obtained directly from the Dyeing and Finishing Laboratory at Universiti Tun Hussein Onn, Faculty of Civil Engineering. The bamboo powder used in this study is the by product from the extraction process of bamboo fibre through a steam explosion process. Then, bamboo powder are immersing in the NaOH solutions for 24 hours at room temperature. After the chemical treatment process, the bamboo powder are wash under running tap water until all traces of excess alkali are completely remove. Finally, the bamboo powder were oven dried at 50 °C for 24 hours before start to another process. Then, the bamboo powder was sieve before motion to the next step. [9]

• Polypropylene

The polypropylene container lunch box used is obtain at RnR Pagoh. The Polypropylene - PP5 lunch box or lunch container has been used in this study which is, Polypropylene plastic is used because it is durable and lightweight, and it has great heat - resistant properties. It protects against moisture, grease, and chemicals. After collected of the polypropylene – pp5 lunch container. Its need to be cleaned from oil, grease and other particulate matter had been stick to this container. Then, all polypropylene – PP5 lunch container needed to cut into small pieces after cleaned the container and before ceiling development process.

• Resin

Resin of Semiconductor has been used on this study, supplied by ST Muar which is one of electronic industry had been used for moulding compound thus it's also high temperature semiconductor applications of electronic industry. The properties of the resin was black and small pieces. And in additional its physical of resin was a black and it's contained from epoxy based. The component that in resin was mainly epoxy and hardener, silica, carbon and other additives.

2.2 Methods

The technique of creating composite ceiling boards from of natural and waste materials including bamboo powder, polypropylene plastic containers, and resin waste from semiconductor coating is discussed. The performance of the composite ceiling board is evaluated at various material proportions. Then, tensile strength, water absorption, thermal conductivity, and resistance tests are used to characterize them based on their physical qualities. This study's flowchart technique is illustrates in Figure 1.

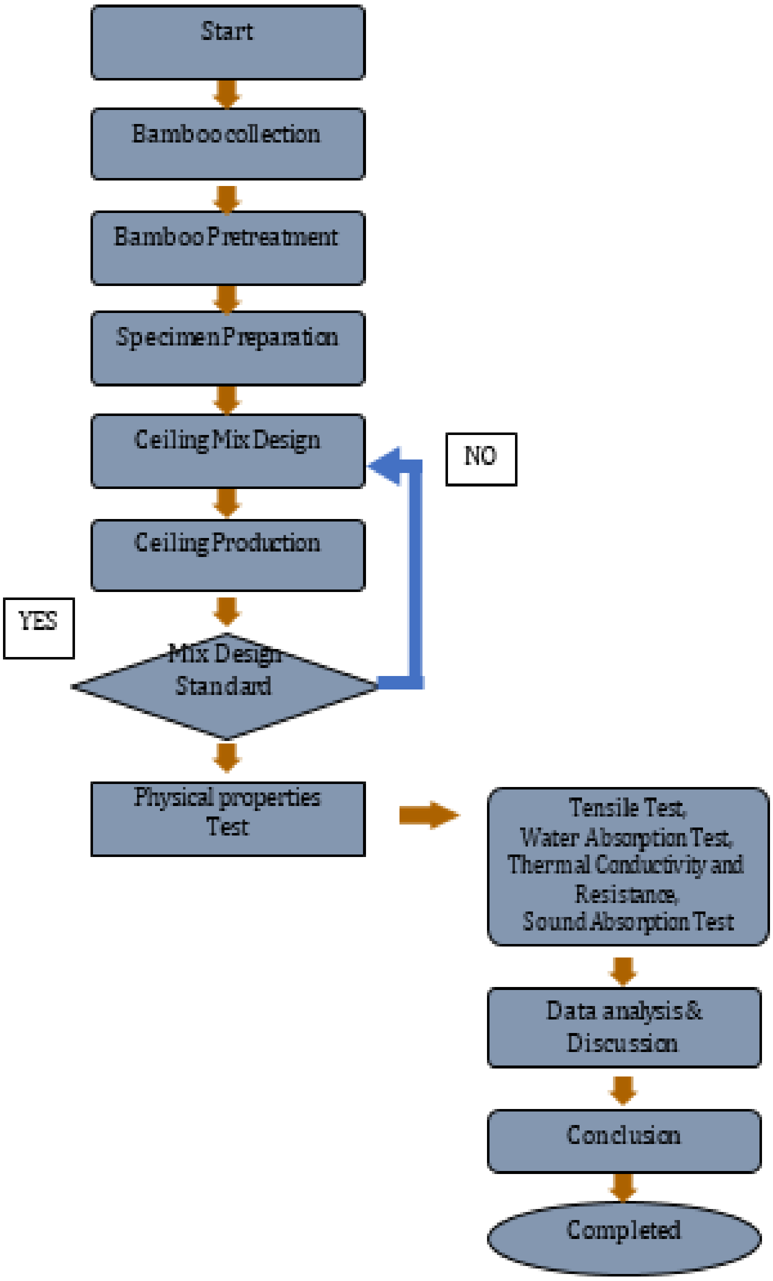

Figure 1: Flow chart of methodology

2.3 Testing of method

Tensile testing, water absorption testing, thermal conductivity and resistance testing, and sound absorption testing were all performed. Furthermore, each testing technique adheres to the American Society for Testing and Materials (ASTM) process standard. For the tensile

- Tensile strength

The specimens for this test were 25 mm x 150 mm x 3 mm thick with a standard test method for tensile properties of plastics that specifies methods for testing the tensile strength of plastics and other resin materials and calculating their mechanical properties, as well as outlines accuracy requirements for the test frames and accessories used. Ultimate tensile strength, maximum elongation, and decrease in area by Eq. 1 are properties that may be directly quantified via a tensile test. These observations may also be used to calculate Young's modulus, Poisson's ratio, yield strength, and strain-hardening characteristics by Eq. 2.

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

$$\mathrm{E} = \frac{\sigma}{\varepsilon} \quad Eq.2$$

- Water absorption

In this section, the specimens for this test was 25 mm x 150 mm x 3 mm of thickness, the water absorption test is performed by immersing the specimens in water for 24 hours until the sample weight stabilized referring to ASTM standard D570. Water absorption is expressed as in weight percent by using Eq. 3.

$$= \frac{Wet\ Weight - Conditioned\ Weight}{Dry\ Weight} \times 100 \quad Eq.3$$

- Thermal conductivity and resistances

In this study, thermal conductivity and resistance measurements were taken to calculate the heat flow with temperature for the ceiling board. The test was determined using the formula below:

$$q = -kA\,\frac{\partial T}{\partial x} \quad Eq.4$$

$$k = -\,\frac{q\,.\,x}{A\,(T2 - T1)} \quad Eq.5$$

$$= -\frac{q}{A}\,({}^{W}/_{m2}) \quad Eq.6$$

$$q = \frac{\Sigma\, Toverrall}{\Sigma\, Rth} \quad Eq.7$$

- Sound absorption

In this section, to calculate the coefficient absorption for the ceiling board, sound absorption was performed. The test was created by combining the calculations in Eq. 8 and 9. Thus, in this investigation, impendence tube results were obtained utilizing acoustic software.

$$a = \frac{Absorb\ sound\ energy}{Sound\ energy\ applied\ to\ the\ surface\ material} \quad Eq.8$$

$$a = \frac{1}{S}\Sigma aiSi \quad Eq.9$$

3. Results and Discussion

3.1 Results

3.1.1. Tensile strength

In this section, as in Figure 2 illustrated the tensile strength of sample 3 is 58.2 MPa is higher values and 46.06 MPa is lowest values for sample 1. For the tensile strength on samples with ratio 70PP: 18BW: 12RC with high tensile strength values. The sample 3 has a high tensile strength rating because tensile strength is the highest tensile force a material can endure before breakage. It is a measure of a material's resistance to tensile failure, and non-uniform plastic deformation begins at necking. Tensile strength is the ability of a material to resist tension by being pulled apart. By reinforcing with natural fibres, this feature will be substantially increased, as the natural fibres will sustain the majority of loads, hence increasing the strength of the composite material. Tensile strength will grow as the proportion of fibres added increases, and these fibres will be dispersed across a vast area. [3]

The Young's Modulus of sample 2 is 16.75 GPa is higher values and 14.48 GPa is lowest values for sample 1. For the Young's Modulus for samples with ratio 80PP: 12BW: 8RC with high elasticity strength values. Young's modulus measured a material's resistance to elastic deformation under load. In sample 2, a stiff material with a high Young's modulus changes forms only minimally under elastic stresses. In sample 1, a flexible material with a low Young's modulus alters its form or distance apart by two.

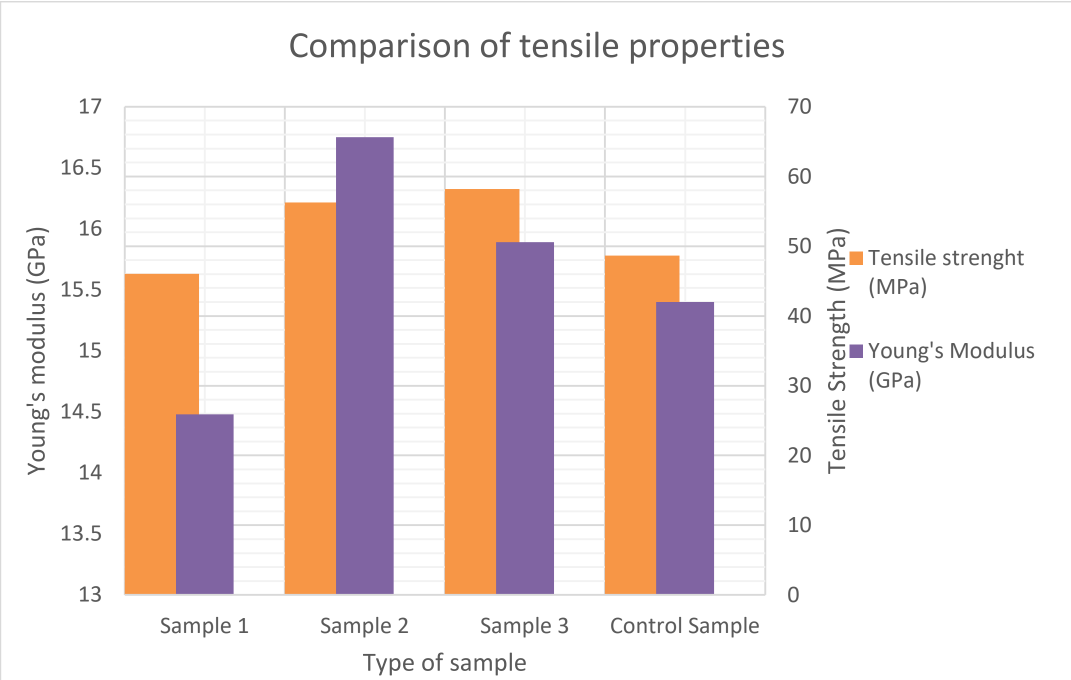

Figure 2: Comparison of Bamboo fibre fraction on Young's Modulus (GPa) and Tensile Strength (MPa)

3.1.2. Water absorption

In this section, as illustrated shown in Figure 3. The water absorption of ceiling composites rises as the fibre concentration increases. Sample 3 has a greater water absorption value of 1.48 %, whereas the control sample has the lowest value of 1.12 %. In the ceiling composite samples, the percentage weight gained increases as the weight fraction of bamboo waste increases. Due to the absence of bamboo waste and fewer faults in the microstructure, the sample acquired the least weight. Furthermore, the absence of fibres is thought to minimize micro-voids and entrained air. [4][5]

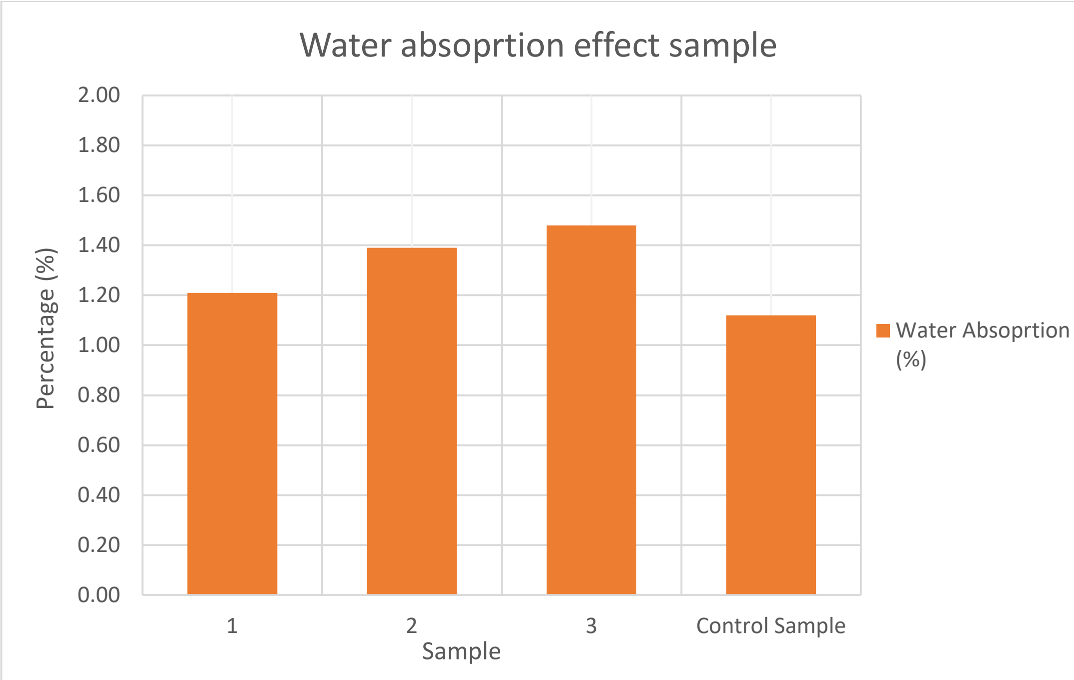

Figure 3: Water absorption effect on Samples

3.1.3. Thermal conductivity and resistance

In this section, as the illustrated below Figure 4. The thermal conductivity of sample 1 was 0.0112 W/mºC is higher because the polypropylene was conducted less heat energy. Then, low values for thermal conductivity is sample 2 was 0.0076 W/m'C. Besides that, thermal resistance of sample 2 was 4.358 ºC/W higher values thermal resistance because of in generally, the higher the thermal resistance the better, because there is a greater resistance to heat transfer. And the lowest values for thermal resistance is sample 1 was 2.966 ºC/W. Several factors influenced thermal conductivity, including material density, moisture content, and ambient temperature. The thermal conductivity value rises as the density and moisture content of the material rise. [6]

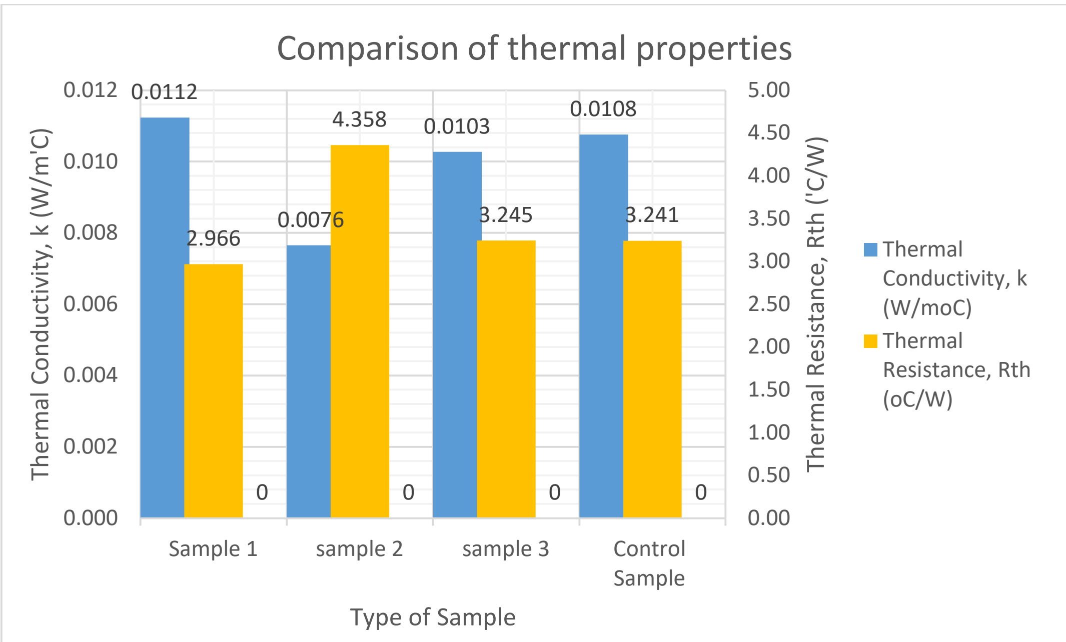

Figure 4: Thermal properties on Thermal conductivity and thermal resistance against sample

3.1.4. Sound absorption

In this section, tests for low frequencies are conducted. To all four samples had a circular design using a sample size of 10cm within 3mm of thickness for this low frequency test. Based on the data released by sample 1 for sound absorption testing for low frequency, at 137.5 Hz is the highest value with a sound absorption coefficient of 0.051. At 512.5 Hz, the lowest sound absorption coefficient is -1.250. The greatest sound absorption coefficient for sample 2 is 0.112, which occurs at a frequency of 62.5 Hz. While the lowest sound absorption coefficient is merely -0.139 at a frequency of 512.5 Hz. The maximum sound absorption coefficient in sample 3 is 0.132 at a frequency of 62.5 Hz. While the lowest sound absorption coefficient is merely -0.139 at a frequency of 512.5 Hz. As a result of the tests performed, sample 4 has a low frequency sound absorption rate as follows. At a frequency of 87.5Hz the sound absorption coefficient is 0.027 which is the highest sound absorption coefficient in this sample. While -0.078 sound absorption coefficient at 487.5Hz frequency is the lowest reading.

Figure 5, illustrated the sound absorption characteristics of the created composites with various sample ratios determined using the impedance tube technique of determining the sound absorption coefficient of the sample panel by standing wave method. Sample 3 has a greater sound absorption coefficient than sample 1, which has a lower sound absorption coefficient.

The sound absorption coefficients of wool boards can be enhanced at low frequencies by increasing the sample thickness. However, at high frequencies, this method has little impact. Thus, increasing the thickness of wool boards increases sound absorption coefficients insignificantly when the boards fulfil the criteria for sound absorption coefficients at low frequencies. The result indicates good sound absorption at high frequencies over 3000 Hz using a bamboo sample of 2 cm length and sample thickness. By reducing the air gap across the sample, the absorption coefficient at lower frequencies can be improved. As previously stated, sample 3 was the best. However, if the addition of micro-holes results in nearly no change in acoustic performance, then samples with longer structure can be predicted to improve at lower frequencies. [7][8]

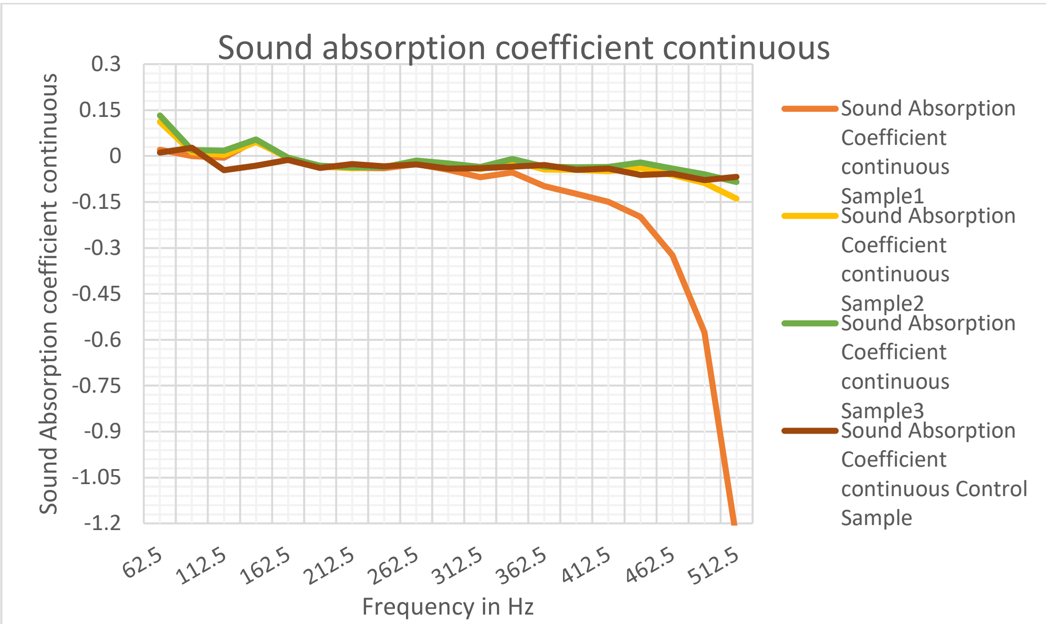

Figure 5: Sound Absorption Coefficient continuous effect Frequency (Hz)

4. Conclusion

Conclusion, the objectives it can be concluded that the panels testing and development of ceiling panels from bamboo was successful. For the first objective is to produce three sample ratios and one control samples of ceiling panel sample designs from polypropylene, bamboo powder, and resin carbon. In addition, the four ceiling panels that have been built measure 300 x 300 mm with 3mm thickness of ceiling panels. For the objective was achieved with the result of three sample ratio and a control sample of ceiling panel designs of different designs which is for sample 1 the proportion design was 90.00 % Polypropylene: 6.00 % Bamboo powder: 4.00 % Resin Carbon, for the sample 2 was 80.00 % Polypropylene: 12.00 % Bamboo powder: 8.00 % Resin Carbon, the sample 3 which is 70.00 % Polypropylene: 18.00 % Bamboo powder: 12.00 % Resin Carbon and the control sample was 70.00 % Polypropylene: 30.00 % Bamboo powder. Second objective was to evaluate the performance of the ceiling board panel in terms of durability, strength, and sound absorption. The determined the influence of the development of ceiling panel design from Polypropylene, bamboo waste, and resin carbon on the tensile test, sample 3 for tensile strength and sample 2 for young's modulus was chosen. The best sample for sound absorption coefficient was sample 3, which was also obtained after testing all four samples at the UTHM laboratory. Thus, from the tests that have been conducted, it is proven that bamboo can be a good binder mixture for composite materials, but the design mix proportional produced does not give a significant difference in the reading for the ceiling panel.

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