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17 November 2016

NOTICE OF RESEARCH ABSTRACT ACCEPTANCE

Jon Val T. Casidsid and co – authors
Romblon State University
Odiongan, Romblon

Dear Sir Casidsid and co - authors:

Congratulations!

Your research abstract submitted entitled **"thermal and Acoustic Properties of Tiger Grass Pollen Insulation Material..............."** is accepted for presentation in the 2016 National Research Conference on "**Creating Connections, Building Bridges, Collaborating and Innovating Philippines Education through Research Dissemination**" to be held on 14 – 16 December 2016 at Queen Margarette Hotel, Lucena City.

Please prepare a 15 – minute PowerPoint presentation of your paper encompassing the introduction, objective/s, methodology/ies, significant findings of the study for purposes of the activity. Likewise, if you desire to publish your work with us, you may prepare a 12 – 15 page **Executive Summary** of your research with the following parts: Title, author/s, institutional affiliation, institutional address, your 150 – 250 word abstract, 5 keywords, introduction, comprehensive review of related literature and studies, methodology (all parts), results, discussion and references. Submit the copy of the foregoing document to the Conference secretariat upon registration. Use Times New Roman font 12 in preparing your document with 1.5 spacing.

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Thermal and Acoustic Properties of Tiger Grass Pollen Insulation Material with Arrow Root Starch as Binder

during the

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held on 14 – 16 December 2016
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drying temperature and time for Lato *(Caulerpalentillifera)* is the combination of 60°C for 30 hours.

Keywords: *Lato (Caulerpa lentillifera), Drying temperature optimized drying temperature, chemical properties*

Thermal and Acoustic Properties of Tiger Grass Pollen Insulation Material with Arrowroot Starch as Binder

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Abstract

Tiger grass pollen is disregarded as a valuable agricultural waste; thus this study explored its potential and beneficial use as an alternative building insulation material with arrowroot starch as binder. Samples were prepared with the following mix proportions. Mixture A: 250 grams - tiger grass pollen and 100 grams - arrowroot starch which is equivalent to 40% of the tiger grass pollen weight. Mixture B: 250 grams - tiger grass pollen and 125 grams - arrowroot starch which is equivalent to 50% of the tiger grass pollen weight. Mixture C: 250 grams - tiger grass pollen with 150 grams - arrowroot starch which is equivalent to 60% of the tiger grass pollen weight. The samples were air-dried for 10 days. The thickness of the particleboards ranges from 8 mm to 10 mm. Based on the tests conducted for acoustic properties, thickness swelling, water absorption, and thermal conductivity, Mixtures B and C demonstrated acceptable results having met the allowable limit values. The

particleboard produced was cheaper and eco-friendly because the main ingredients of the material used were organic and found locally. Thus, it proved that tiger grass pollen can be of great help in the society particularly in the construction industry. As a recommendation, apply some surface treatments to avoid the occurrence of molds or fungi caused by the binding agent. In addition, conduct further study on how to employ a combination of tiger grass pollen with other agricultural waste products to enhance the quality of the particleboard for building insulation.

Keywords: *tiger grass pollen, insulation material, particle board, arrowroot starch, building insulation*

Development of a Cost Efficient Renewable Energy Conversion Laboratory Equipment

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Abstract

Due to the increasing demand of clean energy, more and more efforts in research, education and development of renewable energy and green technology is needed. It is imperative that a course in renewable energy conversion be included in the curriculum of any engineering course. Theoretical discussions in the classroom during lecture hours are not sufficient. It should involve actual application of knowledge. Laboratory activities use the methodology of "learning by doing" wherein activities and workshops simulates the environment of the actual conditions in the industry. However, current laboratory equipment in renewable energy conversion technologies are quite expensive and imported abroad. The project develops a cost efficient and stand- alone laboratory training module and equipment. The materials are locally available in the community and can be designed and fabricated by technicians who are knowledgeable in electricity, electronics and mechanical technology. The training module includes renewable energy sources such as solar, wind, hydroelectric, piezoelectric and kinetic energy. These energy conversions can be stand alone experiments or can be combined and incorporated altogether to teach energy harvesting. It is capable of charging a 6 volt battery and lighting of a 6 volt LED bulb.

THERMAL AND ACOUSTIC PROPERTIES OF TIGER GRASS POLLEN INSULATION MATERIAL WITH ARROWROOT STARCH AS BINDER

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ABSTRACT

Tiger Grass (*Thysanolaena maxima*) pollen is disregarded as a valuable agricultural waste; thus this study explored its potential and beneficial use as an alternative building insulation material with arrowroot starch as binder.

Samples were prepared with the following mix proportions. Mixture A: 250 grams - tiger grass pollen and 100 grams - arrowroot starch which is equivalent to 40% of the tiger grass pollen weight. Mixture B: 250 grams - tiger grass pollen and 125 grams - arrowroot starch which is equivalent to 50% of the tiger grass pollen weight. Mixture C: 250 grams - tiger grass pollen with 150 grams - arrowroot starchwhich is equivalent to 60% of the tiger grass pollen weight. The samples were air-dried for 10 days. The thickness of the particleboards ranges from 8 mm to 10 mm. Based on the tests conducted for acoustic properties, thickness swelling, water absorption, and thermal conductivity, Mixtures B and C demonstrated acceptable results having met the allowable limit values.

The particleboard produced was cheaper and eco-friendly because the main ingredients of the material used were organic and locally available. Thus, it proved that Tiger grass pollen can be of great help in the society particularly in the construction industry.

As a recommendation, apply some surface treatments to avoid the occurrence of molds or fungi caused by the binding agent. In addition, it is suggested to conduct further study on how to employ a combination of tiger grass pollen with other agricultural waste productsto enhance the quality of the particleboard for building insulation.

Keywords: Tiger Grass pollen, insulation material, particle board, arrowroot starch, building insulation

INTRODUCTION

Tiger grass (*Thysanolaena Maxima*) is one of the most commonly cultivated grasses locally grown in the Philippines and it looks similar to bamboo and sugarcane. Tiger grass has a variety of uses and it plays a valuable role as the main material for broom production. The bamboo-like stalks make strong handles and the dried flower panicles are tied together to make the broom parts. The fibers (panicles) of this plant are already proved its importance and life span because it is being used in handicraft production that is why this fiber performs certain strength that could resist loads applied into it.

One of the most important challenges of future buildings is the reduction of energy consumptions in all their life phases, from construction to demolition. Through that, building insulations were developed and commonly realized using materials obtained from petrochemicals (mainly polystyrene) or from natural sources processed with high energy consumptions (glass and rock wools). These materials cause significant detrimental effects on the environment mainly due to the production stage like use of non-renewable materials and fossil energy consumption, and to the disposal stage like problems in reusing or recycling the products at the end of their lives.

Due to global warming problem, the use of thermal insulation materials sustain the comfortable temperatures in living environments or in building which became rampant in recent years. The use of thermal insulation is regarded as one of the most energy-efficient improvements and means of energy conservation in buildings. As the largest building component, it plays an important role in achieving buildings' energy efficiency. This will result in decreasing the cost of cooling as well as decreasing the pollution of the environment. Talking about energy consumption, both commercial and residential buildings spent almost half of primary energy resources and trend to increase in the future.

Most of the farmers know that tiger grass is used only as a broom component but specifically, the other part of it particularly the pollen grain which is being totally thrown and burnt is conspicuously used as another product which could also benefit mankind. Through that, the researcher conducted this study for the reason of finding out if pollen grains of the tiger grass can be utilized as building insulation material that are usually used in homes, schools, and offices like cork board, furniture and the likes. In addition, this study was conducted to be able to produce or create an economical and profit-oriented product for human consumption or utilization. This study also aimed to produce durable particleboard as insulation materials for structural applications from locally source materials by using tiger grass pollen in conjunction with different natural binders. This is in effort to reduce the rate of importation of synthetic fibers and make locally made building materials available at a cheaper rate.

REVIEW OF RELATED LITERATURE AND STUDIES

Related Literature

Particleboards are relatively new type of engineered wood product that are made from gluing together small chips, sawdust, saw shavings, recycled wood, agricultural residue, etc. According to Khosravi (2011), particleboard is a wood-based composite that is used for many applications such as furniture, flooring, panels and the likes. Particleboards consist of wood particles glued together at high temperature and pressure. The particles are separated based on size after they have been dried, the sizes of the particles are of great importance and will influence the properties of the final product. Normally, particleboards have three layers namely (a) core layer with coarser particles and a lower density, and (b) two surface layers with finer particles and higher densities.

The Australian Standard (AS/NZS 1859) gives limit values for certain mechanical and physical properties. The Tables 1 and 2 below shows typical values of these properties (rather than limit values) presented in 3 thickness classes.

Table 1. Thickness Classes

Thin	up to 12 mm thick
Medium	13 –22 mm thick
Thick	more than 23 mm thick

Table 2. Typical Property Values for Standard Particleboard

Property	Units	Thickness Class - mm		
		<=12	13 - 22	>23
Density	kg/m^3	660 - 700	660 - 680	600 - 660
Bending Strength (MOR)	MPa	18	15	14
Bending Stiffness (MOE)	MPa	2800	2600	2400
Internal Bond Strength	MPa	0.6	0.45	0.40
Surface Soundness	MPa	1.25	1.30	1.30
Screw Holding - Face	N	-	600	700
Screw Holding - Edge	N	-	700	750
Thickness Swell (24 Hr)	%	15	12	8
Formaldehyde E1 (Desiccator Method)*	mg/l	1.0 –1.5	1.0 –1.5	1.0 –1.5

Related Studies

According to Suleiman, Aigbodion, Shuaibu, and Shangalo (2013), today's renewable biomass is mostly accepted as waste materials and are mostly ploughed into the soil or burnt in the field. According to the end uses of wood-wastes and their possible reuse products, particleboard has found typical applications as flooring, wall and ceiling panels, office dividers, bulletin boards, furniture, cabinets, counter tops, and desk tops and it seems that the manufacture of particleboard from recycled wood-based wastes is the most common way to reuse such waste materials. Also, one of the major challenges associated with wood-based particleboard is the use of formaldehyde resin. Formaldehyde is a volatile, colorless gas with a strong odor that is commonly used in industrial processes, particularly in manufacturing building materials. Pressed wood products, such as wood-based particleboard and medium density fiberboard, are made using adhesive resins containing urea-formaldehyde. Off-gassing levels are at their highest when the products are new, with emissions tapering off as they age. Exposure to formaldehyde in concentrations greater than 0.1 parts per million (ppm) can cause nasal and throat congestions, burning eyes, or headaches as well as increasing the risk of developing cancer.

According to Ismail et al. (2012), the feasibility of Arenga Pinnata fiber to be applied for acoustical material component indicated that, there are different binders namely polyurethane, urea formaldehyde and latex. The weight percentages of binder used were 10%, 15%, 20%, 25% and 30%. Hand lay-up process was used in specimens' production. The physical, acoustical and durability properties of the panels were investigated experimentally. The value indicates that Arenga Pinnata panels are highly absorptive materials. However, Arenga Pinnata panel is poor insulator since the optimum sound transmission loss is only 9.7 dB from panel added with 15% polyurethane at 5000 Hz. Thus, Arenga Pinnata panel is applicable to reduce echo caused by reflection effects within a room. Sound absorption increases as porosity increase and decrease as density-tortuosity increase. Hence, Arenga Pinnata fiber is applicable for acoustical component panel. Moreover, ArengaPinnata panels are durable that resist water, heat and fire. It is applicable for heat insulation.

In the study entitled "Possible Applications of Corncob as a Raw Insulation Material" conducted by Pinto, Sá, Pereira, Bentes, and Paiva (2011) revealed that corncob has been treated as an agricultural waste. Finding practical applications of this waste in product manufacturing may preserve the environment and may also allow using more green technologies. Therefore, a corncob particleboard, a lightweight concrete for nonstructural purposes, and a lightweight concrete masonry unit (CMU) are the granulated corncob-based products proposed. The study allowed estimating the thermal conductivity of the granulated corncob and of the granulated corncob particleboards. The density and the thermal properties of this alternative solution are in accordance with the properties of the currently used expanded clay concrete. It shows that this agricultural waste may have potential as a thermal insulation product.

According to the study conducted by Faustino, et al. (2012) entitled "Impact Sound Insulation Technique using Corn Cob Particleboard", the affordability and low rate of CO_2 emissions to the atmosphere, and small energy and water consumptions are some parameters that should be taken into consideration when a product is designed. Using green building materials which must be renewable, local and abundant is a solution that contributes to achieve these important goals. Using different agricultural products such as bagasse, cereal straw, corn stalk, corn cob, cotton stalks, kenaf, rice husks, rice straw, sunflower hulls and stalks, banana stalks, coconut coir, bamboo, durian peel, and oil palm leaves were proposed for product processing such particleboard, hardboard and fiber board, and focusing on their thermal insulation ability. Other types of residue such as newspaper, honeycomb and polymeric waste were also proposed for product processing of different building components.

On the other hand, new alternative sustainable sound insulation building products have been at the center of society's concerns. Sound insulation products processed with natural materials such as cotton, cellulose, hemp, wool, clay, jute, sisal, kenaf, feather and coco or processed with recycles materials like wood, canvas, foam, bottle, jeans, rubber, polyester, acrylic, fiberglass, carpet and cork are some solutions already established. These green products or eco-products intend to be sustainable alternative to the traditional ones like glass or rock wool. The fact that natural fibers may be economic, light weight and environmentally friendly, it justified that these fibers have been studied as an alternative to synthetic fibers in the acoustic context. Among the mentioned agricultural products, corn cob has an additional advantage in terms of possible application for alternative processed products because it does not collide with worldwide food stock and it is generally considered as agricultural waste.

Lodewijks et al. (2008) and Enqkvist et al. (2007) showed thermal insulation has the best cost abatement profile to reduce greenhouse gas emissions. To quantify the environmental benefits in the use phase by using thermal insulation the related (operational) energy reduction has to be calculated first. In relation to that applying thermal insulation in buildings is recognized as one of the most cost effective methods to reduce energy consumption. The benefits of applying thermal insulation in buildings are dependent on the geographic location where the building is situated. Introducing thermal insulation with a same thickness and material composition in a similar building (and orientation) and building element composition in Northern and Southern Europe has a different effect, as in the warmer climate the amount of heat which could be saved is lower, since the days of heating and the difference between internal and external temperatures is greater in Northern Europe for both measures.

According to Monier et al. (2011) thermal insulation is only recently a mainstream event and buildings tend to have a long life span, the amount of insulation coming out of (partly) demolished buildings is still relatively small. Different insulation producers have set up takeback and recycling systems related to construction waste and production waste. Nevertheless, the amount of recovered waste only represent a small fraction of all C&D waste (Construction and Demolition Waste) and is often not enough to make recycling and (energy) recovery processes profitable (PE NWE, 2011). End-of life environmental impacts for thermal insulation are not only dependent on the material composition of the product, but also on the disposal route chosen. Disposal scenarios vary significantly between European countries, as in some regions such as Flanders landfill bans are placed on recyclable fractions of Construction and Demolition waste (C&D waste), and in other countries such as Germany plastic and biomass based insulation are used for energy recovery. In Germany, also, high rates were achieved although there are no national bans on landfilling of C&D waste material. In Spain, however, the lack of control of unauthorized landfills and the high differences in landfill taxes between regions were identified as the main barriers to the recovery of C&D waste.

According to the study conducted by Fetalvero (2011), Marigondon Norte is a tiger grass growing village in San Andres, Romblon. It is located in the north eastern part of the municipality along the lush and rolling mountains of central Tablas. It is bounded by San Agustin in the east and Calatrava in the north. It has an approximate total land area of 2,800 hectares and is home to about 221 households of 1,175 people (NSO, 2005). Most of the tiger grass farms were owned by farmers but some were tilled by tenants. It was very common to see farms that were 2 km away from homes. Although some farms were situated just beside homes, others were located as far as 5 km away. The farm area estimates range from 0.3 to 9 has with an average of 1 hectare per farmer. The total farm size was 130.6 hectares distributed in the following locations: Ambunan (39 has), Hagnaya (37.8 has), Naruntan (24.75 has), Lindero (14.3 has) Hagimit Big (7.75 has) and Hagimit Small (7 has). This study proved that the supply of tiger grass pollen is enough to produce an insulation material out of it.

METHODOLOGY

A. Preparation of the Adhesive

The following are the procedures in the preparation of the adhesive using the arrowroot starch:

1. Prepare the materials needed for the adhesive –arrowroot starch, water, spatula, casserole.

2. Dissolve 100 grams of arrowroot starch in a ½ cup of water (Adhesive 1) and set aside.

3. Boil 1 cup of water.

4. Pour the mixture on the boiling water.

5. Stir the mixture until it becomes clear and sticky.

6. Repeat the procedure 2 to 5 using different combination such as; 125 grams of arrowroot starch in a ¾ cup of water (Adhesive 2) and 150 grams of arrowroot starch in1 cup of water (Adhesive 3) for the remaining mixtures.

B. Production of the Particleboard

The following are the procedures in the production of the particleboard:

1. Prepare the materials needed for the particleboard – adhesive, Tiger Grass pollen, paper wax, stirring rod/spatula, container/basin, molder and block of wood weighing 10.5 kg as compressor.

2. In a container/basin, combine the tiger grass pollen and the adhesive. (a) 250 grams of tiger grass pollen and Adhesive 1; (b) 250 grams of tiger grass pollen and Adhesive 2; and (c) 250 grams of tiger grass pollen and Adhesive 3.

3. Mix it well until the tiger grass pollen is completely bonded by the adhesive.

4. Set up the molder and cover the inner surface of the molder entirely with paper wax to prevent any bonding reaction between the molder and the mixture.

5. Distribute the mixture into the molder evenly.

6. Press the mixture well using a block of wood.

7. Remove the sample from the molder.

8. Get the weight wet of the sample.

9. Subject for air-drying for ten days until completely dried.

10. Get the weight dry of the sample to get the moisture content.

11. Repeat the procedures stated for the production of the desired number of samples.

Table 3 shows the three mix proportions prepared for the study. Every sample mixture has three samples indicating the amount of the Tiger Grass pollen, arrowroot starch, and water as the main ingredients for the mix.

Table 3. Mixing Proportion of the Particleboard

Mixture	No. of Sample	Amount of the Tiger Grass Pollen (g)	Amount of Arrowroot Starch (g)	Amount of Water Used for Binder
Mixture A	Sample 1	250	100	1 ½ cup
	Sample 2	250	100	1 ½ cup
	Sample 3	250	100	1 ½ cup
Mixture B	Sample 1	250	125	1 ¾ cup
	Sample 2	250	125	1 ¾ cup
	Sample 3	250	125	1 ¾ cup
Mixture C	Sample 1	250	150	2 cups
	Sample 2	250	150	2 cups
	Sample 3	250	150	2 cups

C. Preparation of Particleboard for Thickness Swelling and Water Absorption Test

1. In each mixture, provide three samples subject for the testing.

2. Cut the samples for each mixture into two with a surface dimension of 0.15 m x 0.15 m.

3. Subject for testing half of the cut sample without paint and the other half coated with an Enamel White Paint.

4. Soak the samples for each mixture in water for two hours.

5. After two hours, weigh the samples, measure and compute the thickness swelling and water absorption.

D. Testing of Acoustical Properties

1. Fabrication of Testing Chamber - The dimension of the testing chamber is 0.7 m x 0.6 m for the base and 1.0 m for its height with a volume of 0.42 m^3 to accord with the specimen area of 0.09 m^2. The chamber is an enclosed space made of plywood and studs.
2. Installation of Specimen in the Testing Chamber - Install the specimen for each mixture occupying the three faces of the chamber, three specimens for each face.

E. Test for the Determination of Peak Amplitude

Loud speaker is outside the chamber at fixed point for all types of mixture with varying frequency and intensity of sound having the microphone probe inside the chamber. The microphone probe is connected to a magnetic tape recorder for data storage and future measurement or reference. The software used in determining the peak amplitude was Cool Edit Pro which giving the data which are recorded, analyzed and summarized. Statistical analysis was done using a computer program.

F. Testing for the Determination of Thickness Swelling and Water Absorption

The determination of 2-hour water absorption (WA) and thickness swelling (TS) tests were performed according to ASTM D-1037. After 2 hours, the uncoated/natural and coated samples with paint were taken out from the water and reweighed and remeasured for its thickness. The water absorption of each specimen was calculated by the weight difference. The water absorption and thickness swelling of each specimen were prepared with a surface dimension of 0.15 m x 0.15 m.

$$\textbf{Thickness Swelling(TS)} = \frac{t_f - t_i}{t_i} x100\%$$

Where:

t_i = initial thickness of the sample

t_f= final thickness of the sample

Thickness Swelling (TS) is expressed in percentage.

$$\textbf{Water Absorption (WA)} = \frac{w_f - w_i}{w_i} x100\%$$

Where:

w_i = initial weight (dry) of the sample

w_f= final weight (wet) of the sample

Water Absorption is expressed in percentage.

The test was done in terms of moisture content (MC) and dry density of the samples. In computing the thermal conductivity of each sample, the formula derived by Siau (1983) was used as cited by TenWolde, McNatt, and Krahn, (1988). Thermal conductivity is being computed to determine how much electric current or amount of heat the sample can receive before it yields.

Process:

1. Get the moisture content of the sample (MC) with a formula of:

$$MC = \frac{Ww - Wd}{Ww} \times 100\%$$

2. Get the dry density of the sample (ρ) with a formula of:

$$\rho = \frac{W_{dry}}{V}$$

3. Solve for the thermal conductivity (k) with a formula of:

$$k = 0.509547 - 0.471983(a)$$

Where:

k = thermal conductivity of the sample

a = Porosity = $\sqrt{(1 - 0.000667D - 0.00001MD}$

M = moisture content of the sample

D = dry density of the sample (kg/m^3)

RESULTS AND DISCUSSION

A. Peak Amplitude Data

Table 2 sows the results of the peak amplitude per mixture. Comparing the result of the three mixtures, Mixture C has the lowest peak amplitude of -15.68 dB which means the intensity of sound being absorbed is low while Mixture A recorded the highest peak amplitude of -14.01 dB which means there's no effect in the intensity of sound being absorbed as it compares to the peak amplitude recorded by the empty room which is -14.08 dB. Mixture B recorded peak amplitude of -15.31 dB.

Table 4. Comparison of Result using Different Mixture

	Empty Room		Mixture C		Mixture B		Mixture A	
	Left	Right	Left	Right	Left	Right	Left	Right
Min Sample Value:	-7513	-6401	-6336	-5389	-5537	-4713	-7332	-6261
Max Sample Value:	7630	6481	6154	5244	6571	5621	7674	6528
Peak Amplitude:	-12.66 dB	-14.08 dB	-14.27 dB	-15.68 dB	-13.96 dB	-15.31 dB	-12.61 dB	-14.01 dB
Possibly Clipped:	0	0	0	0	0	0	0	0
DC Offset:	0	0	0	0	0	0	0	0
Minimum RMS Power:	-32.79 dB	-34.19 dB	-33.83 dB	-35.2 dB	-34.89 dB	-36.27 dB	-35.03 dB	-36.39 dB
Maximum RMS Power:	-15.74 dB	-17.13 dB	-21.62 dB	-23.01 dB	-21.51 dB	-22.9 dB	-20.51 dB	-21.9 dB
Average RMS Power:	-24.71 dB	-26.1 dB	-29.4 dB	-30.78 dB	-29.92 dB	-31.3 dB	-28.91 dB	-30.29 dB
Total RMS Power:	-24.26 dB	-25.65 dB	-29.12 dB	-30.5 dB	-29.75 dB	-31.13 dB	-28.59 dB	-29.97 dB
Actual Bit Depth:	16 Bits	16 Bits	16 Bits	16 Bits	16 Bits	16 Bits	16 Bits	16 Bits

B. Thickness Swelling

The determination of 2 hours thickness swelling (TS) test was performed according to ASTM D-1037. After 2 hours, the specimens which are uncoated/natural and coated with paint were taken out of the water for the measurement of its thickness. The thickness of each specimen was calculated by the thickness difference. The thickness swelling of each specimen was prepared with a surface dimension of 0.15 m x 0.15 m. Table 5 shows the results for the three mixtures, comparing uncoated or natural and coated with paint before and after soaking.

Table 5. Thickness Swelling (TS) of the Uncoated/Natural and Coated with Paint Samples before and after Soaking

Thickness Swelling (TS) in Percentage (%)			
Mixture	**No. of Samples**	**Uncoated/Natural**	**Coated with Paint**
Mixture A	Sample 1	13%	37.5%
	Sample 2	11%	33.33%
	Sample 3	11%	0%
Mixture B	Sample 1	11%	11%
	Sample 2	11%	11%
	Sample 3	11%	11%
Mixture C	Sample 1	0%	22.22%
	Sample 2	0%	10%
	Sample 3	10%	20%

The thickness of the samples that ranges from 8mm to 10 mm subjected for testing were considered as thin particleboard according to Australian Standard (AS/NZS 1859). The thickness of the particleboard under thin category ranges from 0 to 12 mm thick. Table 3 shows the thickness swelling of the uncoated/natural and coated with paint samples. The percentage of thickness swelling of the uncoated/natural samples attained a value which ranges from 0% to 13% and does not exceed the maximum percentage of thickness swelling which is 15% according to Australian Standard (AS/NZS 1859). On the other hand, coated with paint samples revealed that only Mixture B samples acquired a percentage of thickness swelling which is 11% that does not exceed the standard maximum value of thickness swelling. Therefore, Mixture B samples were considered as good particleboard for the reason that it passes one of the properties of particleboard which is the thickness swelling.

C. Water Absorption

The determination of 2-hour water absorption (WA) test was performed according to ASTM D-1037. After 2 hours, the specimens which are uncoated/natural and coated with paint were taken out from the water and reweighed it. The water absorption of each specimen was calculated by the weigh difference. The water absorption of each specimen was prepared with a surface dimension of 0.15 m x 0.15 m.

Table 6. Water Absorption (WA) of the Uncoated/Natural and Coated with Paint Samples before and after Soaking

Water Absorption (WA) in Percentage (%)					
Mixture	No. of Samples	Uncoated/ Natural	Coated with Paint	Average %	
				Uncoated/ Natural	Coated with Paint
Mixture A	Sample 1	220%	153.33%	203.64%	148.10%
	Sample 2	200%	122.22%		
	Sample 3	190.91%	168.75%		
Mixture B	Sample 1	100%	133.33%	111.11%	118.71%
	Sample 2	100%	87.5%		
	Sample 3	133.33%	135.29%		
Mixture C	Sample 1	146.15%	88.23%	139.83%	107.33%
	Sample 2	160%	143.75%		
	Sample 3	113.33%	90%		

As indicated in Table 6, the percentage of water absorption of uncoated/natural and coated with paint samples is shown. For uncoated/natural sample, Mixture A showed the highest water absorption of 220% and Mixture B revealed the lowest water absorption of 100%. For samples coated with paint, Mixture A still got the highest water absorption of 168.75% and Mixture C attained the lowest water absorption of 87.5%. By getting the average percentages of water absorption for uncoated/natural and coated with paint sample, Mixture B showed the lowest value of percentage of water absorption which is 114.91% and considered as good particleboard for the reason that it pass one of the properties of particleboard which is the water absorption.

D. Thermal Conductivity

The test was done in terms of moisture content (MC) and dry density of the samples. In computing the thermal conductivity of each sample which the formula derived by Siau (1983) was used. The surface dimension of the sample used was 0.15 m x 0.15 m. Thermal conductivity is being computed to determine how much electric current or amount of heat the sample can receive before it yields. The calculated value for Mixture C met the standard or comparable to ovendry wood particleboard.

Table 7. Thermal Conductivity of the Samples

Mixture	No. of Sample	Weight Wet (g)	Weight Dry (g)	Dry Density Kg/m^3	Moisture Content %	Porosity (a)	Thermal Conductivity W/m-K
Mixture A	Sample 1	125	50	277.78	60	0.9026	0.078
	Sample 2	300	75	370.37	75	0.8351	0.111
	Sample 3	137.5	68.75	339.51	50	0.8986	0.080
Mixture B	Sample 1	187.5	75	370.37	60	0.7285	0.1626
	Sample 2	150	75	370.37	50	0.7535	0.1505
	Sample 3	150	75	370.37	50	0.7535	0.1505
Mixture C	Sample 1	150	81.25	401.23	45.83	0.8884	0.085
	Sample 2	137.5	75	333.33	45.45	0.9089	0.075
	Sample 3	162.5	93.75	416.67	42.31	0.8921	0.083

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