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Investigation on the use of Coco Coir Polypropylene as Thermal Insulator

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Abstract

Thermal insulators are essential in terms of making structures conducive for people to live in and a nice place to work on. This experimental study aimed to develop a thermal insulator using recyclable materials namely; the coco coir from the coconut fruit and used polypropylene drinking straws. This lead to the assumption that all materials have a property to conduct heat and a material which has low thermal conductivity is an ideal insulator. Observing the physical properties of the coco coir being a composite material and various applications, It was incorporated, as well as the polypropylene used straws being commonly named as plastics gives an idea to make these materials the core components of a product that can be used as a thermal insulator.

Keywords: *Coco coir, construction material, concrete mixture, polypropylene, thermal insulator, waste material*

1. Introduction

These days, people who have means to spend, would like to lead a luxurious and comfortable life. For this, the designing and construction of some of the residential and important public building is done in such a manner that they are least effected by heat, cold sound or electricity. By doing so, the efficiency of doing work also increases.

All those materials which minimize or check the passage of heat, cold, electricity or sound through them are called insulators or insulating materials. Some of them are successful only to check the transfer of heat, when they are known as heat insulating materials. Others may be useful to block the transmission and reflection of sound, when they are known as sound or acoustic insulators, while still others may be useful as electrical insulators.

To achieve these insulating effects, it is essential to either use insulating materials or device special methods of construction or as an alternative use both.

Difference of temperature between outside, inside or between the different parts of the building will result in a transfer of heat from hotter or coolest areas. Heat or cold is transmitted through conduction, radiation and convection.

In buildings, the transfer of heat through solid materials takes place, mostly by conduction. The materials used to check the transfer of heat are known as heat insulators or thermal insulators. These insulators act as a barriers or at least retards the passage of heat. The common materials which are used as heat, insulating materials are cork, quilt, rock wood, loose fills, blanket insulation, aluminum sheets, boards, reflecting appearance and light weight aggregate.

Research are made for the development of a new product that possess low heat conductivity, stable chemically, physically and mechanically at high temperature,

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sufficient resistance to moisture, provide adequate heat resistance of the material, effected by heat or high temperature, porous and fibrous texture, capable to resist shocks and vibrations and economic cost

The study focuses in Coco-coir polypropylene as a thermal insulator which will be used in residential as well as in commercial structural works. It introduces the combination of coconut husk and polypropylene (used straws) as core components of such alternative that is not only abundantly found in the country but the researcher believes that will exhibits thermal performance properties. The research aims to study the properties of Coco-coir polypropylene and differentiate from other conventional product used as thermal insulator for building structures. The proposed product consists of coconut husk, used plastic straws and aluminum foil.

Relative experiments were conducted to compare the thermal properties to assess carefully whether the coconut husk and polypropylene could be an ideal surrogate to the existing thermal insulators which are available in local hardware stores. The study promotes the use of indigenous and non composite materials to the construction industry and also finds mean of helping the environment by using recycled materials to be used as main components of the product. The researcher is most hopeful that this endeavor will further lead the way to a more intensive study for the development of new economical, reliable and efficient construction materials.

With regard to the current status of the Philippines there is an ever growing demand for the development of economical construction materials that complies with the standards of materials. The study will lead to the manufacture of an efficient thermal insulating material yet economical that will provide options over conventional or other materials to home buyers, homebuilders, contractors, and developers.

The study promotes the fabrication of an eco-friendly material through recycling of composite and non-composite waste by-products thus reducing the cost of construction without suffering the aesthetic value of the housing projects.

The design is intended to promote materials within the generally accepted levels of safety, health and ecological consideration.

2. Literature Review

2.1. Coco Coir Polypropylene Thermal Insulator

In the United States residences use thermal insulating materials to insulate their homes by regulating the inside temperature of their houses to the level of their contentment. The American Society of Testing and Materials (ASTM) has provided various methods to test the performance of certain insulators that conforms to the existing uniform product standard suitable for production and consumption of such items and protected by bills to ensure the safety and satisfaction of the consumers [1]. The Philippines being a tropical country having hot and cold seasons raises the need for structural insulation that insinuates a conducive and convenient home.

Polypropylene is one of those rather versatile polymers out there. It serves double duty, both as a plastic and as a fiber. As a plastic it is used to make things like dishwasher-safe food containers. As a fiber, polypropylene is used to make indoor-outdoor carpeting, the kind that you always find around swimming pools and miniature golf courses. It works well for outdoor carpet because it is easy to make colored polypropylene, and because polypropylene doesn't absorb water, like nylon does [2, 18].

The coconut tree that is dubbed as the “tree of life” not only for its fruit but because of the various materials can be produced by processing the different components of the tree [3, 15]. Given that the coconut coir commonly named as the fibers that came from the coconut husk presents thermal insulating property that can be utilized and be a means to develop a thermal insulating material combined with a non-composite material (polypropylene) fabricated in such a way similar to a reflective insulator can somehow be refurbished as an alternative to the existing product today.

2.2. Application and Service Test of Coconut Fiber Cement Boards (CFB) in a Frame House

A 2-experimental house with a total floor area of 53 square meters was constructed utilizing coconut fiber-cement boards (CFB) as construction material and to demonstrate the use of CFB as alternative construction material for walling, ceiling, roofing and base support in upper level flooring of houses and as component in the fabrication of furniture (tables, chairs, desks, etc.), cabinets, boxes and vases inside the house [17-19]. The project also aims to evaluate the performance of CFB in actual service condition.

The main features of the house include; three (3) bedrooms and veranda on the upper level and living, dining, cooking areas and toilet and bath on the first level [16].

Experience in the construction of the model house showed that CFB could be effectively applied to simplify home building process in metal-framed construction system in all areas of application. It also showed that the application of CFB could speed up construction time and therefore reduced construction cost. The metal wall frame system consists of 1” CFB jointed to the angular steel bars (¼” x 1 ½” x 1 ½”) vertical and horizontal studs equally spaced at center at cladding. On the other hand, roof cover consists of 8mm thick 75 cm wide and 75 cm long CFB panels painted with water proof paint [12, 13]. The boards were fastened to the metal purlins (0.60 cm x 3.8 cm x 75 cm channel bars) with the use of umbrella tie wires. For the second level flooring, the 25 mm thick CFB’s were used as formwork, base support and at the same time as the ceiling of the first level flooring. Coconut fiberboards were also successfully used as built-in cabinets and boxes inside the house to serve as tables, chair or desk.

2.3. Coconut Fiber - cement Board as Construction Material

A coconut fiber-cement board (CFB) is a product manufactured from fibrous materials like coconut coir, fronds, spates and shredded wood that are mixed with Portland cement at a predetermined ratio of 60-70% cement to 30-40% fiber by weight [11, 12]. CFB is made by forming the cement-fiber mixture into mats and pressing them to the desired thickness ranging from 8 to 25 mm. The board measures 244 cm long by 61 cm wide. The board density varies from 600-kg/cu.m. to 750-kg/cu.m [13].

Previous studies conducted at PCA-ZRC have shown that CFB panels have good strength properties and high dimensional stability when soaked in water (water absorption of 32% and thickness swelling of 4.2%) surpassing the minimum requirements set by PHILSA-Standard 105-1975 [13, 14]. It has low thermal conductivity (k-value of 0.90 W/mk), which indicate its excellent insulation properties, thus it can be used as roofing materials even without the provision of ceiling. Flame test showed that while the board can be burned, it is rather slow with minimal smoke emission [14].

The recently concluded study on the exposure test of paint-coated CFB roof sheets has demonstrated the capability of the material to withstand the deleterious effect of weathering found in actual service condition. The same study also showed that using Boysen and Dutch Boy brands of paints a much superior performance of roof boards could be expected [12, 14].These two types of coating material have exhibited the ability to provide maximum protections from weathering that other brands of paints failed to give.

2.4. The Composition of the Coconut Coir

At the physical level coir appears similar to peat moss, but there are clear chemical differences. Advanced Nutrients has taken time to develop a detailed understanding of the chemistry of coir and nutrient solutions while designing Monkey Juice [10, 12].

Coir dust is very similar to peat in appearance. It is light to dark brown in color and consists primarily of particles in the size range 0.2-2.0 mm (75-90%). Unlike sphagnum peat, there are no sticks or other extraneous matter. Independent analyses of coir dust were formed in May and June 1991 at Auburn University, University of Arkansas, and A&L Analytical Laboratories [8, 11]

The higher pH of coir dust (compared to peat moss) may allow less lime to be added to a coir dust-based medium, though adding dolomite to container soils is more important for Ca and Mg nutrition than for elevating ph [10]. This study shows that a small amount of nitrogen drawdown (N kept from availability to plants during decomposition of organic amendments low in nitrogen) occurred with coir dust, but typical production practices would likely compensate for the small of regulating N loss. Moreover the coir dust in comparison to sedge and sphagnum peat products and concluded that it has superior structural stability, water absorption ability and drainage, and cat-ion exchange capacity compared to either sphagnum peat or sedge peat [10, 11].

Coir dust tends to be high in both sodium and potassium compared to the other peat, but Na is leached readily from the material under irrigation [11, 12]. The high level of potassium present in coir dust are interesting to note, and may actually prove more a benefit than any detriment of plant growth. Coir dusts from sources other than Sri Lanka have also reportedly contained chlorides at levels toxic to many plants [8]. Thus, it is very important that salinity in the raw material be monitored before processing into a horticultural amendment. It is evident, that chemical properties of this material can vary widely from source to source [9, 11]

So as closer scrutiny, the researcher find out that there is a lot of data to have to consider when planning in using coir as a growing medium. Advanced Nutrients researched these physical and chemical properties and results of many growers to conceive of a complete fertilizer formulation suited for coir.

In designing Monkey Juice for coir, to hold nutrients in solution as long as possible, we use nitrogen and carbon containing chelators; these chelators are organic molecules that are electronegative like the cellulose in coir [7, 9]. Abundant chelation of nutrients is one way to compensate for coir's ability to absorb or "luck-up" nutrients.

In Monkey Juice secondary nutrients and micronutrients are chelated with these diverse and abundant organic molecules that promote their uptake as well as insulating them from cellulose.

Coir is essentially cellulose and lignin, but there are richly electronegative molecules that will "trap" any positively charged atoms that are in solution [8, 16]. After some time absorbing nutrients, this cat-ion-trapping ability of coir, also called cat-ion exchange capacity (CEC), becomes saturated, since the coir's cellulose has a limit or "capacity" for how many cat-ions it can hold at any given ph. The absorptive capacity of coir is high; there is a lot of surface-area in the granular structure of coir, and the electronegative cellulose fibers have a strong effect on all dissolved cat-ions

These cat-ions are not really trapped, as they will "exchange" for other cat-ions in solution. CEC changes with pH; since the hydrogen ion or "H+", the element that pH measures, is itself a very small cat-ion it is also attracted to the electronegative cellulose in coir [16].

Under acidic conditions many more H+ atoms are in solution, and these will displace the other cat-ions readily from the coir, pushing the ionic ally bound salts on the cellulose back into solution. Sudden drops in pH (which means a rise in H+ concentration) can flash-release large amounts of potassium (K+) from the cellulose of the coir [7, 11].

Modern techniques for scientific analysis such as X-ray crystallography have been applied to coir, to determine the exact molecular structure of the cellulose. The scientist reports the following:

"Coir is mainly a multi-cellular fibre which contains 30 to 300 or more cells in its cross section. Cells in natural fibers like coir refer to crystalline cellulose arranged helically in a matrix consisting of a non-crystalline cellulose-lignin complex. Coir has several valuable physical properties which stem from its structure. Among the most useful properties, mention may be made of length, fineness, strength, rigidity, wet-ability, and resistivity" [11].

This kind of analysis reveals that coir is mainly helically formed cellulose bundles. It's inside this cellulose where roots will be trying to uptake solubilized nutrients. Cellulose fibers contain oxygen atoms that are "electronegative" and ionic ally bond to nutrients that have positive charges (cat-ions) [8, 14].

2.5. The Chemical and Physical Properties of Polypropylene

Most commercial polypropylene has an intermediate level of crystallinity between that of Low Density Polyethylene (LDPE) and High Density Polyethylene (HDPE); its Young's modulus is also intermediate [9, 19]. Although it is less tough than HDPE and less flexible than LDPE, it is much more brittle than HDPE [12]. This allows polypropylene to be used as a replacement for engineering plastics, such as ABS. Polypropylene is rugged, often somewhat stiffer than some other plastics, reasonably economical, and can be made translucent when uncolored but not completely transparent as polystyrene, acrylic or certain other plastics can be made. It can also be made opaque and/or have many kinds of colors. Polypropylene has very good resistance to fatigue, so that most plastic living hinges, such as those on flip-top bottles, are made from this material. Very thin sheets of polypropylene are used as a dielectric within certain high performance pulse and low loss RF capacitors. Polypropylene has a melting point of 160 ^{0}C [14].

Many plastic items for medical or laboratory use can be made from polypropylene because it can withstand the heat in an autoclave. Food containers made from it will not melt in the dishwasher, and do not melt during industrial hot filling processes. For this reason, most plastic tubs for dairy products are polypropylene sealed with aluminum foil (both heat-resistant materials) [15]. After the product has cooled, the tubs are often given lids of a cheaper (and less heat-resistant) material, such as LDPE or polystyrene. Such containers provide a good hands-on example of the difference in modulus, since the rubbery (softer, more flexible) feeling of LDPE with respect to PP of the same thickness is readily apparent. Rugged, translucent, reusable plastic containers made in a wide variety of shapes and sizes for consumers from various companies such as Rubbermaid and Sterilities are commonly made of polypropylene, although the lids are often made of somewhat more flexible LDPE so they can snap on to the container to close it [13, 15].

To produce a rubbery polypropylene, a catalyst can be made which yields isotactic polypropylene, but with the organic groups that influence tactility held in place by a relatively weak bond [17]. After the catalyst has produced a short length of polymer which is capable of crystallization, light of the proper frequency is used to break this weak bond, and remove the selectivity of the catalyst so that the remaining length of the chain is tactic. The result is a mostly amorphous material with small crystals embedded in it. Since each chain has one end in a crystal but most of its length in the soft, amorphous bulk, the crystalline regions serve the same purpose as vulcanization.

3. Methodology

In the design of an effective thermal insulator, it must primarily conform to the specified standards of insulating materials that are stated by the American Society for Testing and Materials (ASTM). The ASTM C726-93 provides standard procedures to test the thermal performance of a given insulator, since there are no available measuring instruments in the Philippines [2, 6]. The researcher has improvised physical performance tests to evaluate the level of effectiveness of the coco coir polypropylene insulator. From the several performance tests, the researcher has adopted three thermal properties to assess the level of performance of the innovated material. The thermal properties used in the study are thermal resistance, resistance to flame and moisture absorption.

Thermal resistance is a property of an insulator that is of utmost importance. There are several apparatuses that the ASTM provides to measure the thermal resistance value of a particular insulator, such as the calibrated hot box and dry guarded hot plate [3]. Hence, the researcher improvised a test the thermal insulating performance of the material by subjecting it to a comparative test with the commercial brand in terms of insulation or heat regulation. In ensuring the stage of safety of structures that will acquire such materials, guidelines were stated on ASTM E84-93 to test the material on how it will respond to flame [4, 6]. The researcher also improvised a procedure to compare the materials if they were subjected to direct flame exposure, recording the time of appearance of smoke and actual flame. Finally, the material is then tested for its ability to absorb moisture by observing the rate of its absorption in a seven days span by considering its percentage by weight.

3.1. Materials

The coir fibers with length of 110-120 mm were obtained from the coconut husks abstracted from the coconut fruits naturally grown in Philippines. Literature values for the chemical properties of the coir fiber are presented in Table 1. The fibers were chopped into 12-15 mm length to ensure easy blending with coco matrix. The chopped fibers were then dried at 100^oC for 36 h (Figure 1). The moisture content of the fibers, as determined by oven-dry weight, was found to be 1-2 % prior to the treatment. Virgin Polypropylene ($Tm=160^oC$, $\rho=900\ kg/m^3$, $MFI/230^oC/2.16\ kg= 6.5\ g/10\ min$) was used as the coco material. The Polypropylene was processed by a rotary grinder to pass through a US 40-mesh screen and retained on a US 80-mesh screen. The Polypropylene was chosen as the matrix material in this study because of its good balance of property range, low processing temperature, low price, and good thermal stability [5].

Table 1. Chemical Composition and Microfibrillar Angle of the Coir

Chemical composition and microfibrillar angle	Unit (weight %)
Lignin	40-45
Cellulose	32-43
Hemicellulose	0.15-0.25
Pectin	3-4
Water soluble	5
Ash	2
Microfibrillar angle (degree)	30-45

Figure 1. (a) Coco Coir Fibers. (b) Polypropylene Straws Threaded Together (75cm x 71cm) and (c) Aluminum foil (75cm x 71cm)

3.2. Heat Insulation Performance Test

The researcher devised a method to test the heat insulation performance of the innovated product. An improvised apparatus was made to simulate the actual performance of an insulating material where varying variables were regulated and controlled to attain desirable results. CCP is then compared to the performance of the current insulating material that is available in local hardware stores.

3.2.1. Materials: Miniature design of two (2) residential houses with symmetrical features where actual products will be put to the test by actual placement of insulating materials on the roof part of the improvised instrument, three (3) weather thermometers, Coco Coir Polypropylene (CCP) sample 5mm thick, existing thermal insulator sample 5mm thick and timing device preferably a clock.

3.2.2. Procedure: (1) Put the instrument under the sun in a position where both cabin will receive the same amount of heat radiation from the sun; (2) Synchronize the weather thermometers by placing them on a basin with cold water until all of the thermometers read 0^0C; (3) Record the inside temperatures of both cabins by placing a thermometer on each cabin as well as the outside temperature by placing one outside the instrument on a thirty minutes interval from 11:00 am up to 4:00 pm. Make at least five (5) trial periods the greater the number of trials the more ideal; and (4) Make an average reading of the following temperature readings.

3.3. Absorption Test

The product is subjected to this test to assess its ability to absorb moisture.

3.3.1. Materials: Weighing scale and basin with ample amount of water

3.3.2. Procedure: (1)Weigh the coco coir polypropylene insulator using a weighing scale and record it as its initial weight; (2) Soak the product to a basin with an ample amount of water for seven (7) experimental days; and (3) Weigh the product after the seventh day using the same weighing scale and compute the percentage gained by the product.

3.4. Flame Test

The researcher improvised a procedure to test the material with its reaction to direct exposure to flame. This test is vital to interpret the level of safety of a particular product.

3.4.1. Materials: Two (2) Bunsen burners, sample of the existing insulating product 5mm thickness, CCP sample 5 mm thickness and two (2) stop watch.

3.4.2. Procedure: (1) Set up the holders of the Bunsen burners to similar heights where samples will be placed; (2) 2. Lit both the burners until both burners display the same intensity of flame; (3) Place the two products where each stop clock is assigned to them; and (4) Record the time of appearance of smoke and flame.

3.5. Fabrication of the Coco Coir Polypropylene Thermal Insulator

3.4.1. Materials: Two (2) Bunsen burners, sample of the existing insulating product 5mm thickness, CCP sample 5 mm thickness and two (2) stop watch. Coco coir from coconut husks, binding agent of such kind, aluminum foil, polypropylene (used plastic drinking straws), flat iron and thin threads.

3.4.2. Procedure: (1) Thread coconuts coir removing the husk dusts using a comb; (2) Tie the used straws using thin threads in the form of a mat; (3) Make layers of aluminum foil, coco coir, used straws, coco coir, and aluminum foil respectively. Layers will depend upon the desired thickness; and (4) Compact the product by the use of flat iron to the desired thickness. Make sure that there is an even distribution of heat by even rubbing of the flat iron and make sure there is a thick paper preferably a cartolina so that the aluminum would not shrink too much.

Figure 2 shows the placement and cross section of the materials used in CCP. The upper and lower part is composed of the aluminum foil, followed by the coco coir in both side, and in the middle was the polypropylene (used straw).

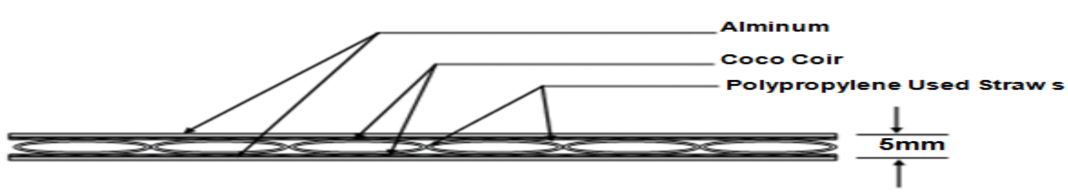

Figure 2. Cross Section of CCP

4. Results and Discussion

4.1. Heat Insulation Performance of Existing Commercial Insulator

Table 1 discusses the temperature readings that were recorded in a thirty minutes time interval. The commercial brand is then compared to a cabin where is no insulation present as well as the temperature reading of the outside surrounding to evaluate the effectiveness of placing thermal insulation. The test was done on a five days testing that started every 11:00 am and ends at 4:00 pm

Table 1. Heat Insulation Performance of Existing Commercial Insulator

	DAY 1			DAY 2			DAY 3			DAY 4			DAY 5			Mean Average		
	CCP	BR	OT	CCP	BR	OT	CCP	BR	OT	CCP	BR	OT	CCP	BR	OT	CCP	BR	OT
11:00 – 11:30 am	29	29	29	28	28	28	28	28	28	29	29	29	30	30	30	28.8	28.8	28.8
11:30-12:00 nn	30	29	31	28.5	30	31.5	28.5	30	31	30	30	31	30	32	31	29.4	30.2	31.1
12:00 – 12:30 pm	30	33	32	30	34	34	29	33	31.5	30	32.5	31	30.5	33	31	29.9	33.1	31.9
12:30 – 1:00 pm	30	34	32	30	34	34.5	30	34	34	30	33	32	31.5	33	32	30.3	33.6	32.9
1:00 – 1:30 pm	30	34.5	33	30	34.5	34.5	31.5	34	33	30	33	32	32	33	32	30.7	33.8	32.9
1:30 – 2:00 pm	30	34.5	34	31	35	35	31.5	34.5	33	30	34	32	32	34	32	30.9	34.4	33.2
2:00 – 2:30 pm	31	35.5	35	32	34.5	34.5	30	35	33	30	34.5	33	32	34.5	33	31	34.8	33.7
2:30 – 3:00 pm	32	35.5	34	32	34	34	30	35	33	31	34	33	32	34.5	33	31.4	34.6	33.4
3:00 – 3:30 pm	31	35	34	31.5	34	33	30.5	34.5	32.5	31	34	33	31	34	32	31	34.3	32.9
3:30 – 4:00 pm	31	34.5	33	31.5	34	33	30.5	34	32.5	31	33	32	31	34	32	31	33.9	32.5

4.2. Heat Insulation Performance of Coco Coir Polypropylene (CCP)

Table 2 discusses the temperature readings that were recorded in a thirty minutes time interval. The coco coir polypropylene is then compared to a cabin where is no insulation present as well as the temperature reading of the outside surrounding to evaluate the effectiveness of placing thermal insulation.

Table 2. Heat Insulation Performance of Coco Coir Polypropylene (CCP)

	DAY 1			DAY 2			DAY 3			DAY 4			DAY 5			Mean Average		
	CCP	BR	OT	CCP	BR	OT	CCP	BR	OT	CCP	BR	OT	CCP	BR	OT	CCP	BR	OT
11:00 – 11:30 am	29	29	29	28	28	28	28	28	28	29	29	29	30	30	30	28.8	28.8	28.8
11:30-12:00 nn	30	29	31	28.5	30	31.5	28.5	30	31	30	30	31	30	32	31	29.4	30.2	31.1
12:00 – 12:30 pm	30	33	32	30	34	34	29	33	31.5	30	32.5	31	30.5	33	31	29.9	33.1	31.9
12:30 – 1:00 pm	30	34	32	30	34	34.5	30	34	34	30	33	32	31.5	33	32	30.3	33.6	32.9
1:00 – 1:30 pm	30	34.5	33	30	34.5	34.5	31.5	34	33	30	33	32	32	33	32	30.7	33.8	32.9
1:30 – 2:00 pm	30	34.5	34	31	35	35	31.5	34.5	33	30	34	32	32	34	32	30.9	34.4	33.2
2:00 – 2:30 pm	31	35.5	35	32	34.5	34.5	30	35	33	30	34.5	33	32	34.5	33	31	34.8	33.7
2:30 – 3:00 pm	32	35.5	34	32	34	34	30	35	33	31	34	33	32	34.5	33	31.4	34.6	33.4
3:00 – 3:30 pm	31	35	34	31.5	34	33	30.5	34.5	32.5	31	34	33	31	34	32	31	34.3	32.9
3:30 – 4:00 pm	31	34.5	33	31.5	34	33	30.5	34	32.5	31	33	32	31	34	32	31	33.9	32.5

4.3. Heat Insulation Performance of CCP and CP

Table 3 discusses the mean average temperature readings of the coco coir polypropylene and the commercial brand which was obtained using the arithmetic mean formula. And by observation we can see that there is a propinquity of obtained results. Figure 3 and figure 4 were prepared for better visual interpretation of the data acquired.

Table 3. Heat Insulation Performance of CCP and CP

	Mean Average	
Intervals	CCP	CB
11:00 - 11:30 pm	28.8	28.8
11:30 - 12:00 nn	29.4	29.4
12:00 - 12:30 pm	30.1	29.9
12:30 - 1:00 pm	30.6	30.3
1:00 - 1:30 pm	30.9	30.7
1:30 - 2:00 pm	31.1	30.9
2:00 - 2:30 pm	31.7	31.0
2:30 - 3:00 pm	31.7	31.4
3:00 – 3:30 pm	31.3	31.0
3:30 – 4:00 pm	30.8	31.0

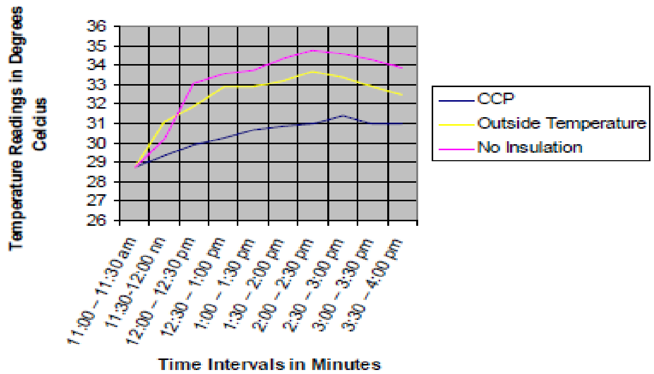

Figure 3. Heat Insulation Performance of CCP

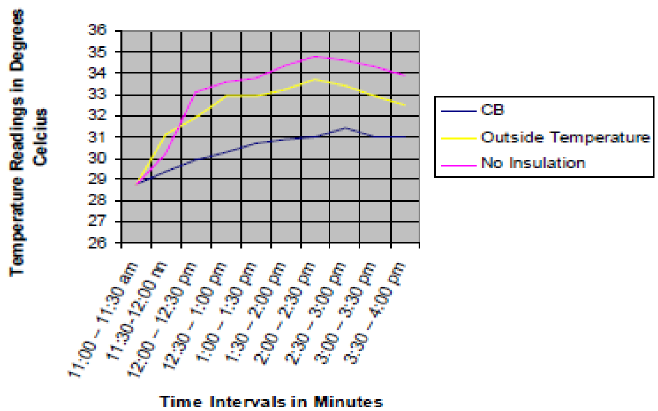

Figure 4. Heat Insulation Performance of CB

Figure 5 shows that the heat insulating performance of the coco coir polypropylene insulator compared with the existing thermal insulating material has a close proximity of results in terms of heat insulation. It may be observed on the following graphical representation that the peak hour wherein the maximum temperature reading is at 33^{0}C at 1:30 pm up to 2:00 pm. Based upon the performed test CCP carry out better outputs with regards to maintaining a the cabins inside temperature longer than the commercialized one and insulates heat more than of the other by having a slow rise of temperature reading inside its cabin in given span of time.

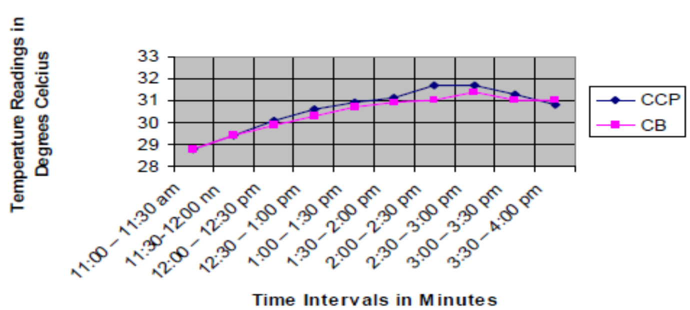

Figure 5. Graphical Representation of the Heat Insulation Performance of CCP and CB

Table 4 shows the outcome of the performed test regarding the absorption of the innovated product reveals an absorption rate of two (2) percent by weight on seven (7) days. The researchers did the absorption test to be able to determine if the product will hold the moisture acquire by the product in times of the sudden change of temperature.

Table 4. Absorption Test

Product	Initial Weight (g)	Final Weight (g)	Absorption (%)
CCP	76.4	77.9	2

Improvised Flame Test is done in an open area, a presence of moving wind but not so strong kind of wind. Considerations were made to limit the affecting variables such thickness of specimen, height of specimen when subjected to flame, level of flame exposure and observations during time intervals. During the test upon the direct exposure to flame is that the coco coir polypropylene at 13 seconds before a smoke become visible while the commercial brand smoke is already present on the first 5 seconds and that after 18 seconds before actual flame is observed while at 16 seconds the commercialized brand is ablaze. Based on the table provided, we can state that CCP has a higher tolerance to flame exposure than of the commercialized brand.

Table 5. Improvised Flame Test

Intervals	0-5	5-10	10-15	15-20	20-25	20-25
CCP	-	smoke	smoke	flame	flame	ablaze
CB	smoke	flame	flame	ablaze	burned up	-

In the duration of the study, the researcher have observed the following outcomes of the performed property performance test experiments, comparing the performance of the two samples on the improvised heat insulation performance test, the coco coir polypropylene compared to the commercialized brand maintains a cooler temperature inside the cabin wherein the apparatus is subjected direct exposure to sunlight and that the performance of the coco coir polypropylene is with close proximity compared to that of the commercial brand.

The ability of a material to react when subjected to flame is important when factors of safety are to be considered. In the improvised flame test wherein both samples were placed simultaneously to direct flame the researchers have observed that CCP has a slower rate of flame tolerance than of the local brand.

The coco coir polypropylene is then soaked to an ample amount of water where it was left for seven experimental days to note the change of weight. It was observed to have absorption of 2% by weight on a seven day trial period

5. Conclusion

Coconut coir and polypropylene exhibits thermal resistance value a thermal property of a material that is of vital importance. CCP show signs of such property that through actual comparative thermal performance executed shows that the innovated product taking into account that it provides a much cooler inside temperature, has a slow rate of heat absorption and being more economical considering its proponents are of recycled materials proves to be a promising item for consumption.

Bearing in mind the actual performance of the product to the controlled performance test with the existing thermal insulator reveals that the product has the ability to insulate heat therefore making it an adept thermal insulator.

6. Appendix

Figure 5. (a) Coco Coir Placement and (b) Truss Frame of the Heat Insulation Test Apparatus

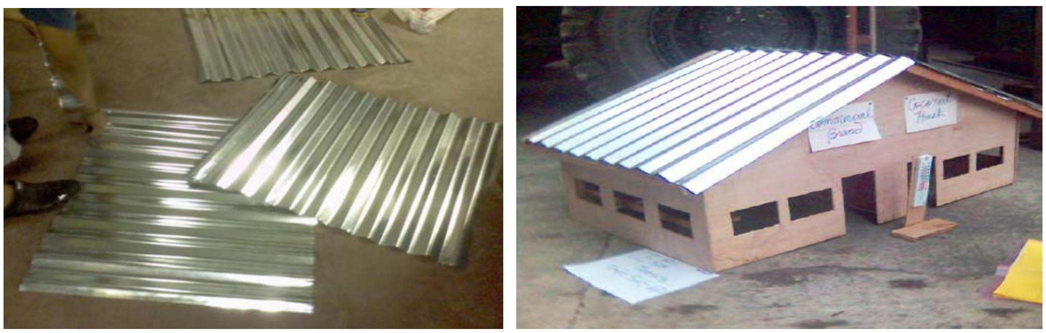

Figure 6. (a) Corrugated Roof Simulate Actual Roof Heat Absorption and (b) Regular Reading of Inside and Outside Temperatures on a 30 min. Interval

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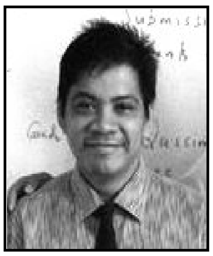

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