Pulverised Dried Banana Fiber Mixed with White Elastomeric Paint as a Thermal Insulator on an External Wall

A PROJECT STUDY PRESENTED TO THE FACULTY OF
College of Engineering

In Partial Fulfilment of the Requirements for the Subject
CE Project 2 (CE 442)

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ABSTRACT

Natural fibers are easily accessible, biodegradable, and safe for human and animal health. The banana is a tropical plant and one of the earth's most widely cultivated and consumed fruits. The leaves and trunk are thrown following the removal of the bananas. Cellulose is one of the most eco-friendly forms of insulation, and it is also one of the most fire-resistant forms of insulation. Research into the thermal insulating properties of plant-based lignocellulose materials has indicated their potential for use in building thermal insulation. At ideal density, the thermal conductivity of these materials fell within the range for use as thermal insulation in buildings. Banana fiber is a viable option for thermal insulation due to its length. Now, this lookup strives to use organic material to be incorporated with paint as a thermal insulator. Modernization commenced, and paint was made with hazardous chemicals. However, this study shows that pulverized banana fibers mixed with white elastomeric paint can be thermal insulators in dwelling walls. The experiment consisted of four samples; Samples 1, 2, 3, and 4. The four setups are placed outside the house where sunlight is easily absorbed. The digital thermometer was placed inside the cubed hollow blocks to get the interior temperature. The temperature was recorded after 1 hour of exposure to heat for twenty-four hours every hour and re-recorded after three weeks for four days. Results showed that Sample 4 had the most significant effect in the thermal resistivity test, and concentrations of pulverized banana fiber had no significant impact on the adhesion tape test.

***Keywords*:-** *Thermal Insulator, Banana Fiber, Improvised Insulator Paint, Banana Fiber Insulator, Pulverised Banana Fiber.*

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CHAPTER ONE
THE PROBLEM AND ITS SETTING

- *Introduction and Review of Related Literature and Studies*

Natural fibers are easily accessible, biodegradable, and safe for human and animal health. Moreover, natural fibers are a feasible alternative to petroleum- and fossil-based fibers. Various portions of plants are gathered for their natural fibers, which are then categorized accordingly. Natural fibers like jute, coir, banana, and sisal are abundant in developing countries like the Philippines, Thailand, and India.

The banana is a tropical plant and one of the earth's most widely cultivated and consumed fruits. The banana tree's trunk is composed of a leaf-like, fibrous substance. Long fibers account for around 1.5% of the plant's total mass on the banana tree. The leaves and trunk are thrown following the removal of the bananas. In the commercial production of bananas, the enormous number of trees imposes additional disposal costs on the farmer. Only a few trees may be used as organic fertilizer in the plantations (Manohar K, 2016).

The majority of the world's bananas are farmed in tropical regions. Almost 60% of banana biomass is wasted after harvest. Approximately 114.08 million metric tons of banana waste are produced globally, which causes environmental issues such as the excessive release of greenhouse gases. These wastes have a high concentration of materials with crucial industrial value, like cellulose, hemicellulose, and natural fibers (Acevedo et al., 2021).

Banana is one of the most consumed fruits in the world. However, it not only provides a high yield of edible carbohydrates with high nutrition but also produces large amounts of pseudostem and rachis residues rich in lignocellulose (Li et al., 2021).

Plant fiber lignocellulose possesses the structure and qualities required for usage as a composite textile material and in pulp and paper production. Additionally, plant-based fiber waste produces fuel, chemicals, enzymes, and animal food. Approximately 2 × 1011 tons of plant-based lignocellulose are generated annually, whereas 1.5 x 108 tons of polymer fiber are created (Manohar K, 2016). This material source is annually renewable, abundantly available, now of low value, and can serve as a cheap source of raw materials for downstream companies. According to Karimah et al. (2021), coconut fiber, sugarcane fiber, cotton, wheat straw, date palm leaves, oil palm fiber, and other lignocellulose fibers offer potential alternatives for use as biodegradable, renewable, eco-friendly building insulation. Developing biodegradable thermal insulation with equivalent performance to non-biodegradable insulation will ameliorate the current environmental problems.

Research into the thermal insulating properties of plant-based lignocellulose materials, such as coconut fiber, sugarcane fiber, and oil palm fiber, has indicated their potential for use in building thermal insulation. At ideal density, the thermal conductivity of these materials fell within the range for use as thermal insulation in buildings. Banana fiber is a viable option for thermal insulation due to its length.

Elastomeric paints are water-based and formulated from acrylic resin. This acrylic system is breathable, can transmit water vapor, will provide waterproof protection for several years, and can be clean with water. New resin systems also give elastomeric coatings excellent color retention and better durability. Elastomeric painting systems are flexible and waterproof, but they can easily be maintained by pressure washing to remove dirt or other contaminants. (Heck, 2003)

Elastomeric paint is a type of paint that forms a barrier against moisture in our structure. In the late 1950s, elastomeric paints evolved into one of the leading coatings used for industrial, commercial, and residential buildings. It can be used in an area of a building continuously being blasted with dampness issues (Parker, 2018).

Mineral Wool, Fiberglass, Polystyrene, Cellulose, and Polyurethane Foam are the five common Thermal Insulation materials. Cellulose is a very eco-friendly form of insulation. It comprises 75-85% recycled paper fiber, usually post-consumer waste newsprint. The other 15% is a fire retardant such as boric acid or ammonium sulfate. Because of the compactness of the material, cellulose contains next to no oxygen within it. Without oxygen within the material, this helps minimize the damage that a fire can cause. Cellulose is one of the most eco-friendly forms of insulation, and it is also one of the most fire-resistant forms of insulation.

Cellulose polysaccharide (C6H10O5)n comprises thermal insulation made from recycled paper or wood fiber mass. The production process gives the insulation material a consistency similar to wool. (Kuba, 2012)

A thermal insulator is a material that stops heat from moving from one place to another. Convection, conduction, and radiation are the three main ways heat travels. A thermal insulator refers to a material that blocks conduction. When something hot physically touches something cold, it is called conduction. To keep cold things warming, use a thermal insulator so that heat cannot move through very quickly. (Tamara, 2017)

Thermal insulation materials are chosen to reduce warmth and glide throughout a medium and can be made of single or multiple materials. Thermal insulation substances save the U.S. industry more than $60 billion/per year in energy charges (Bahadori, 2014).

Having a low thermal conductivity, the thermal insulator is poor for conducting heat. The dairy and food industries used insulation to prevent heat loss and heat gain. Porous is a material containing a large number of air cells. Dairy and food plants use insulating materials like glass wool, polystyrene, and polyurethane foam. However, only some other insulation materials can be used in the dairy and food industries. (Deshmukh, 2017)

Lately, due to the beneficial properties and the fiber's eco-friendliness, the number of technical applications incorporating natural fibers has increased considerably. Many academics have recently concentrated on environmental contamination and depletable petroleum supplies. Every day, the use of natural fibers in scientific research advances. On various plastic substrates, various plant fibers are employed.

A painted elastomeric component successfully withstanding temperatures within the range of at most 32° F and at least 500° F, has desirable flexibility and reflectivity of heat, and is capable of deformation except damage to the paint. Not solely to it face up to this temperature, but it is also thicker than other paint in our market. It is enough to hold the pulverized banana fiber. (Gibbon, R. 1994).

Due to the enormous population of banana plantation in the country, banana is quite helpful in using primary resources in different inventions or research. Banana fiber is additionally observed anyplace; sometimes, we treat it as waste. Nevertheless, this trash is valuable, and it may serve as fertilizer and others. However, in this study, it is presented that pulverized dried banana fibers blended in elastomeric paint can function as thermal insulators in external walls.

- *Conceptual Framework*

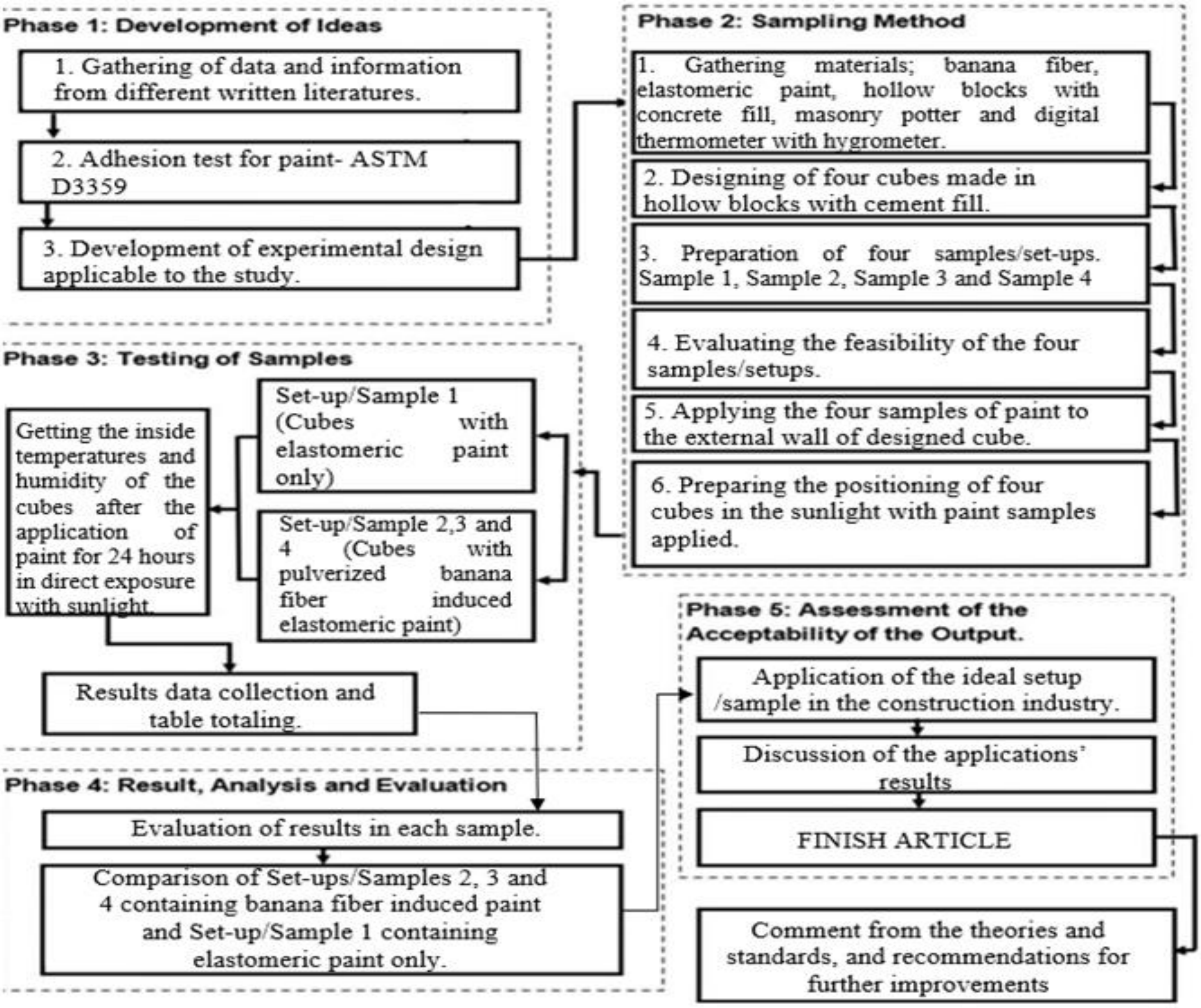

Fig 1 Conceptual Framework of the Study

The conceptual framework of the research is shown in Figure 1. It comprises four stages: idea development, sampling technique, sample testing, result, analysis and evaluation, and assessment of the output's acceptability as an independent variable.

Gathering facts and knowledge based on relevant written literature is a component of Phase 1's Development of Ideas as an independent variable. The main objective of adhesion testing, covered in this section of ASTM D3359 as an adhesion test for paint, is to induce a coating failure. The process of doing research in an objective and controlled way is presented by developing an experimental design, which allows for the maximization of precision and can be drawn regarding a hypothesis statement.

Phase 2 of the sampling method describes how the experiment will be set up. Six steps demonstrate the design of four hollow block cube set-ups and the viability of set-ups/samples 2, 3 & 4 from set-up/sample 1.

Testing of Samples, which takes place in Phase 3, demonstrates how the researcher can assess the inside temperature of the cubes over a specific period when exposed to sunlight and distinguish between the four set-ups. In this section, the researcher will evaluate the performance of each relevant sample for 24 hours after one (1) hour of application and repeat after three (3) weeks to obtain accurate results.

Results, Analysis, and Evaluation, or Phase 4, deals with how well the four sets performed. The findings of this experiment are likewise examined for Set up 1 through 2, 3, and 4. This section will also cover the assessment of the output and applying the optimal set-up in the building industry.

In Phase 5, researchers conduct and discuss the results and recommendations for further study improvements.

➢ *Statement of the Problem*

Low-altitude regions, such as the Philippines and other tropical countries, experience hot climate conditions (Dornolles et al., n.d.). In addition, it adds to the intense sunlight that most Filipinos encounter, whether outside, inside their homes, or offices. At the same time, the impacts of global warming continue to prevail and worsen the already extreme weather conditions. Thermal insulators, such as foam/aluminum insulation boards or reflective paints, are used on buildings' roofs and exterior walls to minimize heat. However, most individuals cannot use this protective equipment since they are out of their price range. The researchers, therefore, look for other options.

The study tests and evaluates pulverized dried banana fibers' effectiveness as a heat insulator. The biomass materials may lessen the heat received by buildings and serve as an alternative eco-friendly and economical insulator. Specifically, this study sought answers to the following questions:

- *In terms of inside temperature, what impact does the ratio of the amount of banana fiber paint have on thermal resistivity?*

✓ *0 Grams (Control)*
✓ *10 Grams*
✓ *15 Grams*
✓ *20 Grams*

- *In terms of adhesion, what is the difference between regular elastomeric paint and elastomeric paint with different pulverized dried banana fibers concentrations?*

✓ *0 Grams (Control)*
✓ *10 Grams*
✓ *15 Grams*
✓ *20 Grams*

➢ *Objective of the Study*

The study's primary objective is to assess the effectiveness of pulverized dried banana fibers when combined with elastomeric paint as a thermal insulator for exterior walls. Specifically, the study aims to focus on the following:

- To develop pulverized dried banana fibers mixed with elastomeric paint.
- To examine two types of paint, banana fiber-induced paint with different concentrations and elastomeric paint, through a thermal resistivity test.
- To examine two types of paint, banana fiber-induced paint with different concentrations and elastomeric paint, through an adhesion test.

- *Significance of the Study*

The findings of this study may be beneficial to countries like the Philippines, Africa, Saudi Arabia, or other hot countries to help them lower the temperature in their households. The paint industry would also gain ideas for innovation in their products. The paint business, in particular, would benefit if this study was successful and evaluated. Individuals researching for the Department of Environment and Natural Research (DENR) might get some ideas from this research. The planet's average surface temperature has risen about 2 degrees Fahrenheit (1 degree Celsius) since the late 19th century, a change driven primarily by increased carbon dioxide emissions into the atmosphere and other human activities (*NASA, 2022*). Banana Fiber-Induced Paint might benefit individuals whose homes are subjected to intense heat.

- *Scope and Limitation of the Study*

Wall paints will be the exclusive subject of this investigation, and no other paints, such as steel paint, will not be considered or tested. The experiment is limited to painting the external walls alone. Black will absorb more light from the sun, which means absorbing more heat, while white reflects more light, meaning it absorbs less energy and heat from the sun. Thus, researchers will select white paint as their primary color choice.

In Bibiclat, Aliaga Nueva Ecija, the banana fiber will be collected. The researcher will determine the optimal relationship of ground banana fiber to white elastomeric paint to create an environmentally friendly thermal insulator for outside walls. The studies will also ascertain how different elastomeric paint ratios and pulverized banana fiber interact.

- *Definition of Terms*

For clarification, the essential terms used in this study have been defined.

ASTM D3359: ASTM D3359 is a standard test method for measuring adhesion by tape test. This test assesses the adhesion of film coatings to metallic substrates by applying and removing pressure-sensitive tape over cuts made in the film. This test method is also known as the Cross Hatch test.

Conduction: the process by which heat or electricity is directly transmitted through a substance when there is a difference in temperature or electrical potential between adjoining regions without moving the material.

Convection: the movement caused within a fluid by the tendency of hotter and, therefore, less dense material to rise and colder, denser material to sink under gravity, which results in heat transfer.

Elastomeric Paint: Elastomeric coatings are protective barriers applied on interior and exterior walls as wall paints. Elastomeric coatings can be water-based coatings and paints or acrylic latex paints. They are applied as a thick coat on concrete structures.

Heat exchanger: A heat exchanger is a system used to transfer heat between two or more fluids. Heat exchangers are used in both cooling and heating processes. A solid wall may separate the fluids to prevent mixing, or they may be in direct contact.

Heat Path: Heat is a path function because when heat transfer occurs, there is some change in temperature in the system and the surroundings. Thus, there must be some work done by or work done on the system, and work done is defined by the path followed.

Insulation: Building insulation is any object in a building used as insulation for thermal management. While most insulation in buildings is for thermal purposes, the term applies to acoustic, fire, and impact insulation.

Thermal efficiency: In thermodynamics, thermal efficiency is a dimensionless performance measure of a device that uses thermal energy, such as an internal combustion engine, steam turbine, steam engine, boiler, furnace, refrigerator, and Acs.

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CHAPTER TWO
METHODS AND PROCEDURE

➢ *Research Design*

In this study, an experimental research design was the most effective method for determining whether elastomeric paint combined with pulverized banana fiber could produce an alternative eco-friendly and cost-effective thermal insulator. Experimental research design is an accurate method because different experiments may be conducted to determine whether the hypothesis is true. The pre-treatment and pulverizing method was adopted from the study of Parkash (2015), Chemical and Mechanical Treatment of Banana Waste to Develop an Efficient Insulating Material, and testing of the inside temperature of cubes or thermal insulation test was acquired from the study of Ratanachotinun and Pairojn (2021), The Development of Paint with Silica Aerogel for Thermal Insulation and Energy Saving.

After applying elastomeric paint containing powdered banana fiber to the cubes, the researchers observed the four set-ups. First, Sample 2, which is 500 ml of Elastomeric paint combined with 10 g of powdered banana fiber, then Sample 3, which is 500 ml of Elastomeric paint mixed with 15 g of pulverized banana fiber, then Sample 4, which is 500 ml of Elastomeric paint mixed with 20 g of pulverized banana fiber, and finally Sample 1, which is 500 ml of elastomeric paint by itself. After one (1) hour application of paint, the temperature inside the cubes is measured with a digital bluetooth enabled thermometer with a hygrometer within twenty-four (24) hours; this will serve as preliminary results. After three (3) weeks, the monitoring of the inside temperature of cubes is repeated for four (4) days. The information provided on the configurations assisted the researchers in concluding.

➢ *Methods*

The following steps are the procedure to perform various tests for banana fiber-induced paint as a thermal insulator. The researchers came up with four (4) samples as set-ups; 0 grams of pulverized banana fiber for sample 1 as the control with 500 ml elastomeric white paint, 10 grams of pulverized banana fiber for sample 2 with 500 ml elastomeric white paint, 15 grams of pulverized banana fiber for sample 3 with 500 ml elastomeric white paint, and the other hand, 20 grams of pulverized banana fiber with 500 ml elastomeric white paint were prepared for sample 4.

- *Preparation of the Banana Fiber*

From the agricultural areas of Brgy. Bibiclat, Aliaga, Nueva Ecija, and one and a half (1 ½) kg of fresh green banana fiber (*Musa acuminata*) were gathered. The samples were carefully wrapped in plastic bags and stored at room temperature in the laboratory.

- *Banana pre-treatment*

The fresh and green banana waste samples were subjected to a preliminary treatment to produce suitable and effective raw material for producing long-lasting insulating material—this material's preparation comprised soaking, washing, drying, grinding, and sieving.

- *Soaking*

In order to eliminate dust particle contaminants, the obtained samples were washed in double-distilled water. The washed banana fiber was then trimmed into short pieces using a pair of laboratory scissors so that the soaking solution could effectively permeate the fiber. At room temperature, 20 grams of Sodium Hydroxide ($NaOH$) were dissolved in 1000 milliliters of distilled water to create a solution containing 2% Sodium Hydroxide $NaOH$. Banana waste was immersed for 24 hours at room temperature in a prepared $NaOH$ solution to remove lignin and prevent fungal or bacterial growth.

- *Washing*

After the banana waste had been soaked, it was thoroughly rinsed with double the amount of distilled water for six (6) hours by dipping it into a 1,000 ml beaker, which helped to reduce the material's concentration of lignin and $NaOH$.

- *Drying*

The cleaned banana waste was oven dried for five (5) hours at 100 degrees Celsius to remove the moisture; ninety-six percent (96%) of moisture was removed after the drying process. After drying the samples, the final weight of the banana trash was calculated using an analytical balance.

- *Grinding and sieving of the material*

The dried previously treated banana waste was processed and powdered using a blender. The waste was broken down into smaller particles. The samples were continually screened using a hand-operated sieve shaker with sieve #200 (75 µm) at the bottom. Forty-five (45) grams of banana fiber were necessary for the study.

- *For the Thermal Insulation Test*

✓ *Step 1*: Prepare four (4) concrete hollow blocks with concrete fill, which will serve as the walls of the cube, and three (3) concrete hollow blocks laid horizontally at the top, which will serve as the roof of the cube. The hollow block cubes have a dimension of 60.32 cm x 40 cm x 30.16 cm.
✓ *Step 2*: Apply a masonry potter on the outer side surfaces of the hollow blocks and let it dry for 1 hour.
✓ *Step 3*: For sample 1, prepare 500 ml of white elastomeric paint. For sample 2, mix 500 ml of white paint and 10 g of pulverized banana fiber; for sample 3, mix 500 ml of white paint and 15 g of pulverized banana fiber. For sample 4, mix 500 ml of white elastomeric paint with 20 g of pulverized banana fiber.
✓ *Step 4*: Gradually apply three layers of paint coatings for each sample with a 0.6-0.8 centimeters thickness.
✓ *Step 5*: After an hour of exposure to sunlight, place the digital thermometer inside the center of the four cubes.
✓ *Step 6*: Using the application of the digital thermometer, the temperature inside is recorded every hour for 24 hours. The data for four set-ups are recorded and tallied.
✓ *Step 6*: After three (3) weeks of application, the temperature inside is re-recorded every hour for 24 hours for four days.

- *For Adhesion Test*

Using ASTM D3359 Method A, also known as the Tape test, the researcher performs this test to determine the adhesion of banana fiber-induced paint.

✓ *Step 1*: Select an area free of blemishes and minor surface imperfections. Ensure that the surface of the concrete hollow blocks is clean and dry. Do the test after one (1) week of paint application.
✓ *Step 2:* Make two incisions or cross-cuts on the surface of hollow blocks with pulverized banana fiber paint about 40 mm (1.5 inches) long and make it intersect with an angle between 30 and 45 degrees. Use straight edges like a ruler when making incisions.
✓ *Step 3*: Inspect the incisions for the reflection of light from the sunlight to determine if the coating is penetrated. If the incision does not penetrate the coating, make another X-incision on the other surface.
✓ *Step 4*: Grab a Tape; use pressure-sensitive tape. Remove two complete laps of the pressure-sensitive tape from the roll and discard. Remove an additional length at a steady, cut a piece about 75 mm or (3 inches), and label it.
✓ *Step 5*: Place the center of the tape at the intersection of the cross incision. Smooth the tape into place with a finger in the area of the incisions and then rub firmly with the eraser.
✓ *Step 6*: Within thirty (30) seconds of application, remove the tape by seizing the free end and pulling it off rapidly, back upon itself at as close to an angle of 180 degrees as possible.
✓ *Step 7*: Inspect the X-incision area for removal of coating from the substrate or previous coating and rate the adhesion following the following scale:

Table 1 Adhesion Test

Ratings	Evaluation Criteria
5A	No peeling or removal
4A	Trace peeling or removal along with incisions or at their intersection
3A	Jagged removal along incisions 1.6 mm (1/16 inch) on either side
2A	Jagged removal along most of the incisions up to 3.2 mm (⅛ inch) on either side
1A	Removal from most of the area of the X under the tape
0A	Removal beyond the area of the X

➢ *Locale of the Study*

To completely expose the samples to sunlight, the research will be conducted in Brgy. Bibiclat, Aliaga Nueva Ecija.

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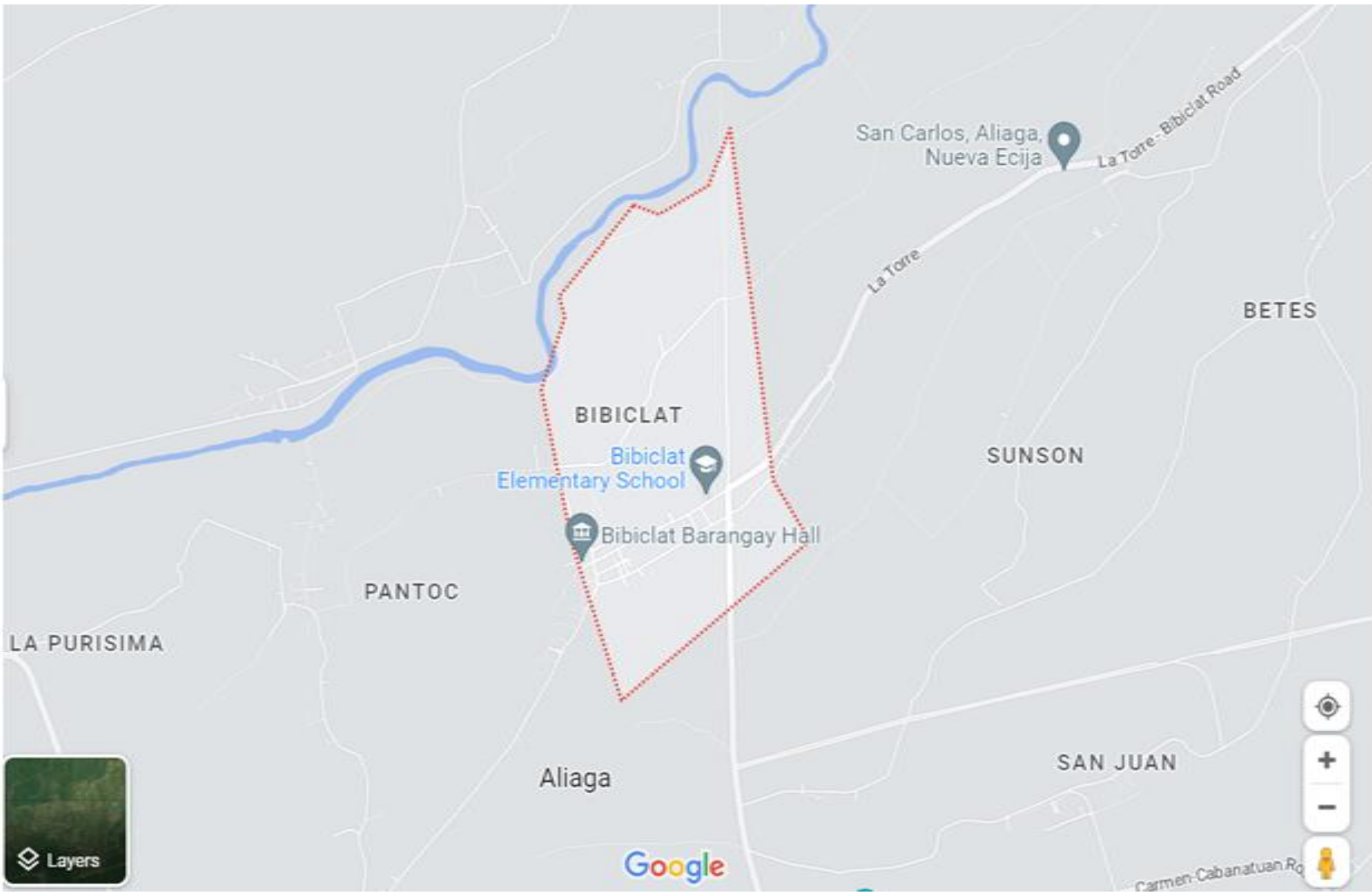

Fig 2 Locale of the Study

➢ *Research Instrument*

The researchers conducted research on the subject and rapidly located literature and articles related to their research. The researchers also perused books and journals, which uncovered helpful information.

The researchers also used a thermal resistivity test to assess if elastomeric paint mixed with pulverized banana fiber could provide an alternative eco-friendly thermal insulator and if the most significant amount ratio of pulverized banana fiber mixed with white elastomeric paint could produce the best thermal resistance.

➢ *Data Gathering*

Gathering of all materials needed for the experimental procedure, such as Banana Fiber, White Elastomeric Paint, Hollow Blocks, and a Digital Thermometer. After gathering all materials, four cubes will be designed for the researchers for the experiment activity. The preparation of four set-ups of mixtures Samples 1-4 set-ups will be implemented. Assessing the results, conducting the best set-up application of the experiment, and discussing the research results, including further recommendations, will be further discussed in the study.

➢ *Data Analysis and Technique*

The following test was conducted to compare the temperature differences of cubes when placed in direct exposure to sunlight using different concentrations of pulverized banana fiber mixed with white elastomeric paint.

The source of banana fiber is the banana stem (banana tree skin); waste is abundant in many parts of the world. Therefore, banana fiber-reinforced paint from the banana stem (banana skin) with high strength and good thermal resistivity properties can be used in many applications. Some farmers use this material for textile applications, while some researchers use this waste in making ropes, mats, woven fabrics, and handmade papers. However, in terms of the construction of houses, paint induced by banana fiber can help pulverize it and mix it with paint; it can be used to reduce the temperature.

The objective was analyzed by measuring the temperature with and without applying pulverized banana fiber-induced paint on external walls. The lower the temperature inside, yields better the result for the study using a digital thermometer. The researchers used comparative analysis by juxtaposing the samples' temperatures.

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CHAPTER THREE
PRESENTATION, ANALYSIS, AND INTERPRETATION

This chapter presents data relative to the problems in the problem statement. The corresponding analysis and interpretation of data are incorporated in this portion of the study.

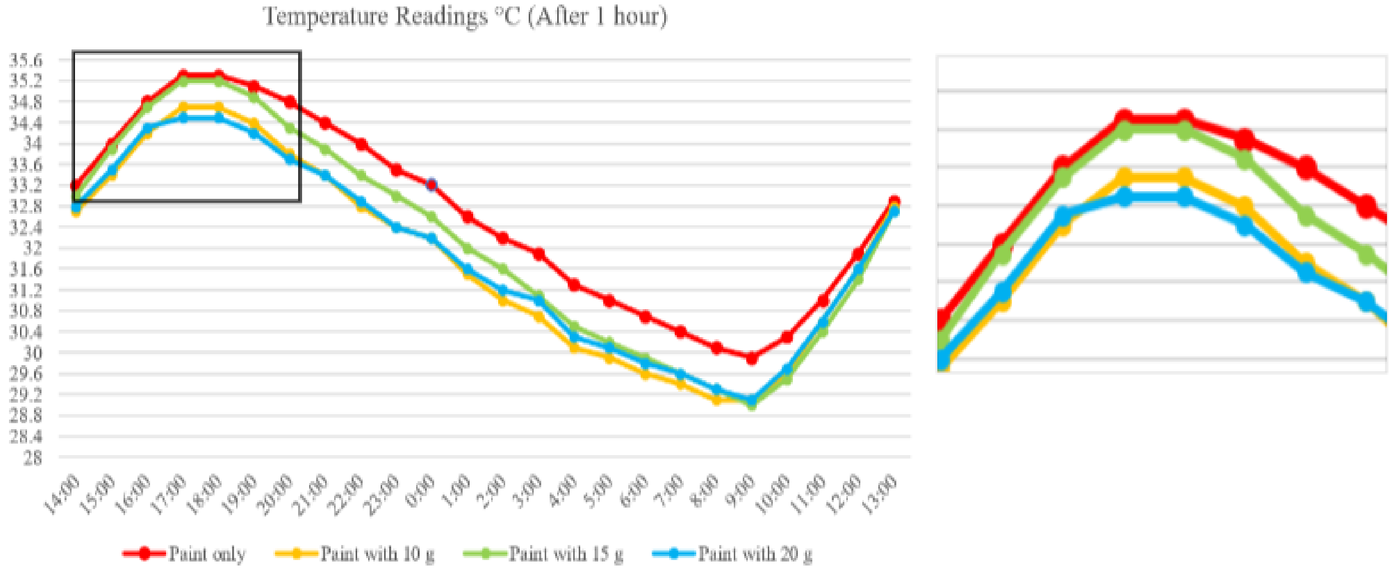

Fig 3 Thermal Resistivity After 1 hour

Sample 1 is 500 ml of White Elastomeric Paint with no pulverized banana fiber mixed. Sample 2 is a mixture of White Elastomeric Paint with 10 g of pulverized banana fiber. Sample 3 is a mixture of White Elastomeric Paint with 15 g of pulverized banana fiber. Sample 4 is a mixture of White Elastomeric Paint with 20 g of pulverized banana fiber.

During the test, the outside temperature in Bibiclat, Aliaga, Nueva Ecija was 36.4 °C. The test was held from 2 p.m. Sunday (April 2, 2023) until 1 p.m. Monday (April 3, 2023). According to the data above, the lowest temperature recorded was 29.1°C at 8:00, and 9:00 AM on Monday, and the highest was 35.3°C at 5:00 and 6:00 PM on Sunday.

Throughout the twenty-four hours of monitoring samples, at 5:00 and 6:00 PM on Sunday, Sample 1 yields the highest temperature for twenty-four (24) hours, while Sample 4, with 20 grams of pulverized dried banana fiber, yields the lowest temperature of 34.5°C.

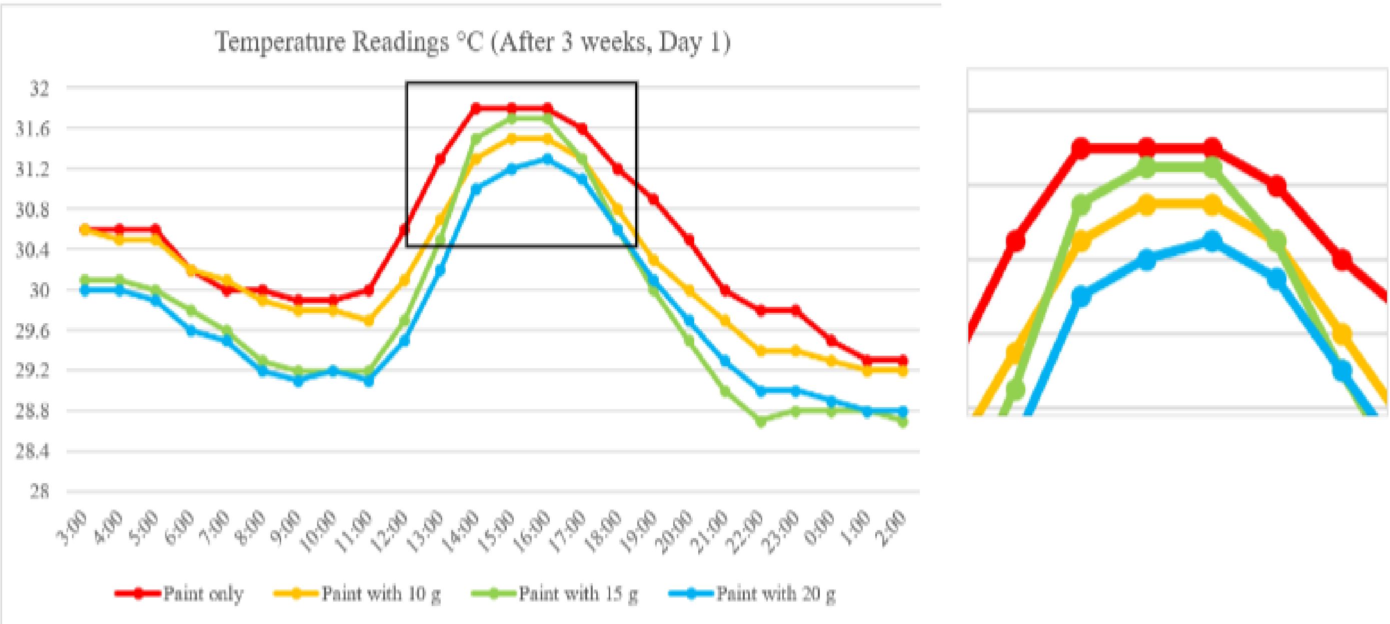

Fig 4 Thermal Resistivity After 3 weeks (Day 1)

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After three weeks (3) of paint application, the inside temperature of cubes is recorded and tallied; the temperature ranges from 28.7°C to 31.8°C in the 24-hour graph. The lowest temperature recorded that day is at 10:00 PM and 2:00 AM at 28.7°C under Sample 3, which has 15 grams of pulverized dried banana fiber concentrations.

The highest temperature recorded was at 2:00-4:00 PM under Sample 1 at 31.8°C; however, at this hottest time, Sample 4 with 20 grams of pulverized dried banana fiber yields the lowest temperatures of 31°C, 31.2°C and 31.3°C.

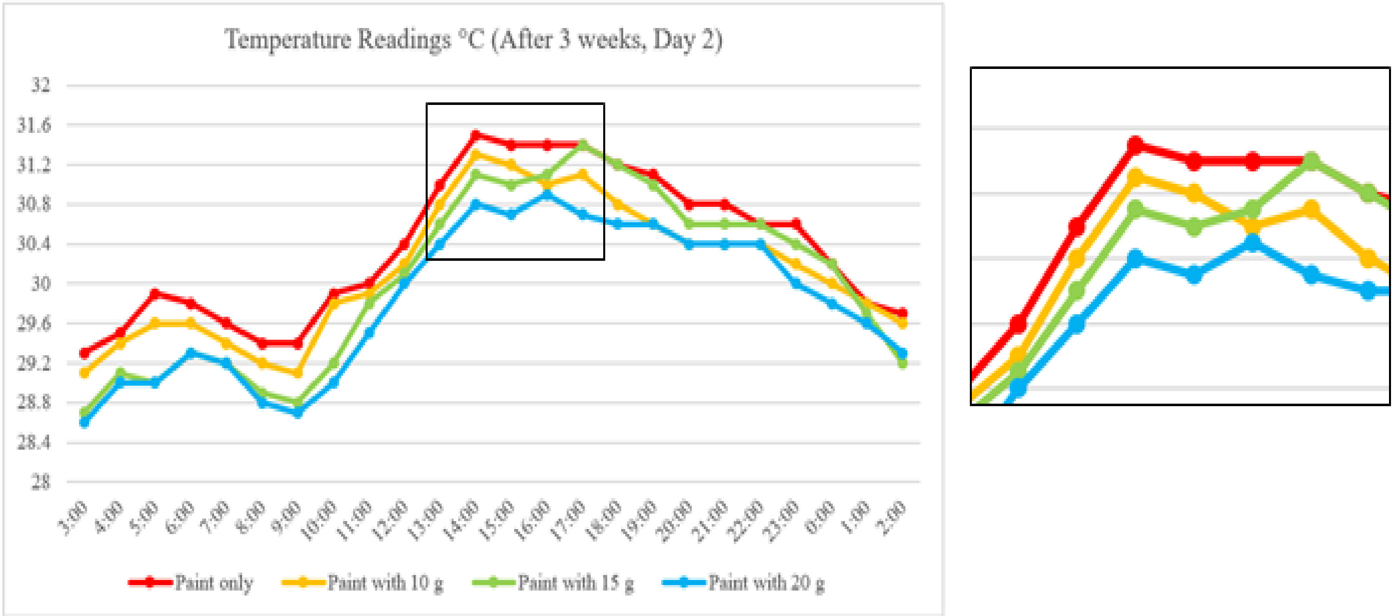

Fig 5 Thermal Resistivity After 3 weeks (Day 2)

Following the application of paint for three (3) weeks, for the second day of the experiment, the inside temperature of the cubes is measured and totaled; the results showed that the temperature ranges from 28.6°C to 31.5°C in the 24-hour graph. Sample 4, which contains 20 grams of pulverized dried banana fiber concentrations, had the lowest temperature measured at 3:00 AM that day. Additionally, Sample 4, with 20 grams of finely ground dried banana fiber, produces a temperature of 30.8°C during the hottest part of the day, while Sample 1 recorded the maximum temperature at 2:00 PM at 31.5°C.

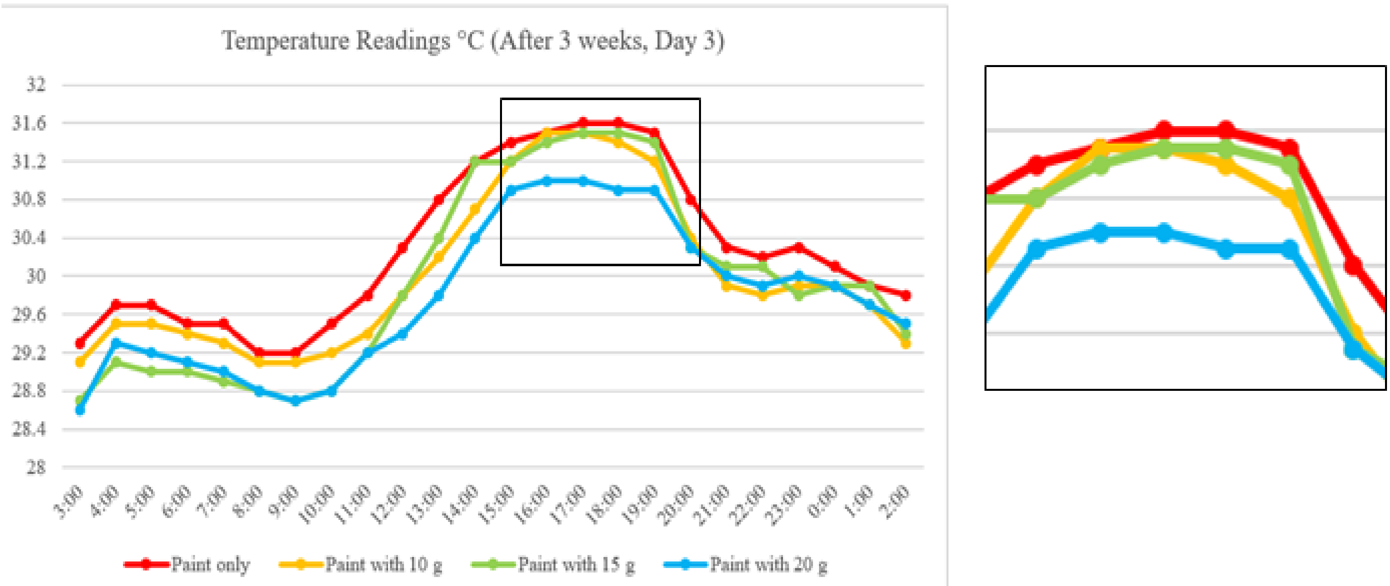

Fig 6 Thermal Resistivity After 3 weeks (Day 3)

Fig 6 shows the measured temperature inside the cubes on the third day of the experiment. Results showed that the temperature ranged from 28.6°C to 31.6°C on the 24-hour graph. Sample 4, which contained 20 grams of pulverized dried banana fiber, had the lowest temperature measured at 3:00 AM that day. Furthermore, Sample 4 produced temperatures of 31°C at 5:00 PM and 30.9°C at 6:00 PM, during the hottest part of the day, while Sample 1 had the highest temperature recorded at 5:00-6:00 PM, which is 31.6°C.

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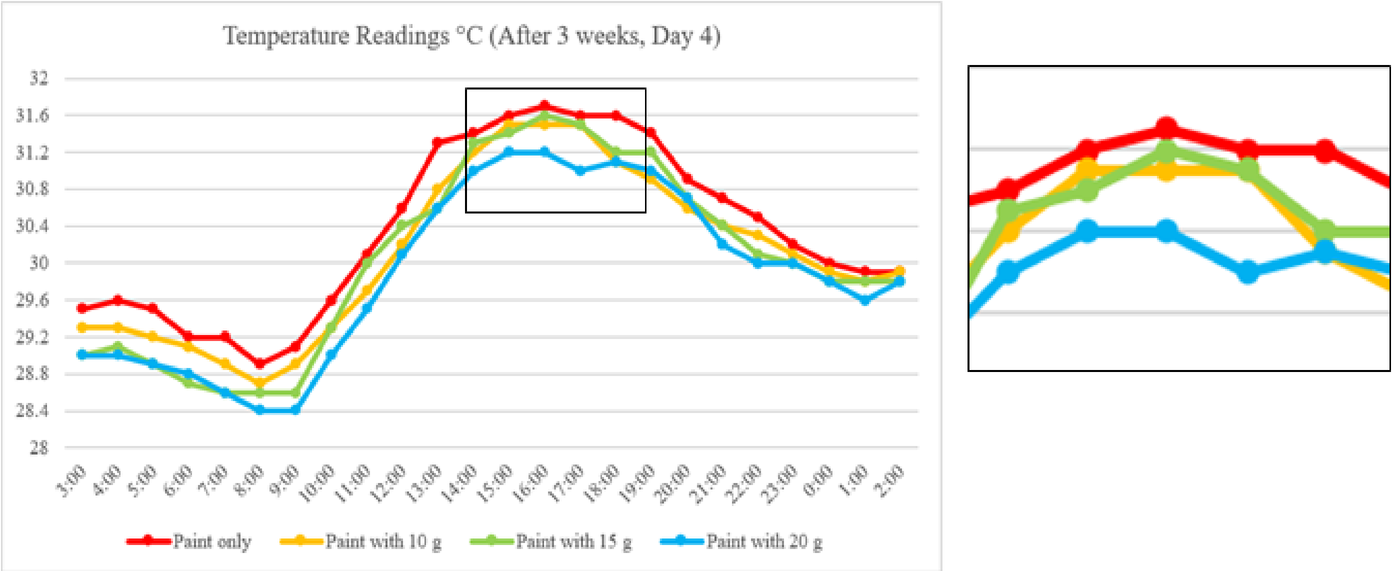


Fig 7 Thermal Resistivity After 3 weeks (Day 4)

Fig 7 shows the Day 4 temperature inside the cubes after applying the paint for three weeks. The recorded data showed the temperature ranged from 28.4°C to 31.7°C on the 24-hour graph. Sample 4, which contained 20 grams of pulverized dried banana fiber, recorded the lowest temperature at 8:00-9:00 AM that day. Sample 1 had the highest temperature recorded at 4:00 PM of 31.7°C. However, during this hottest part of the day, Sample 4, with 20 grams of pulverized dried banana fiber, had the lowest temperature at 31.2°C.

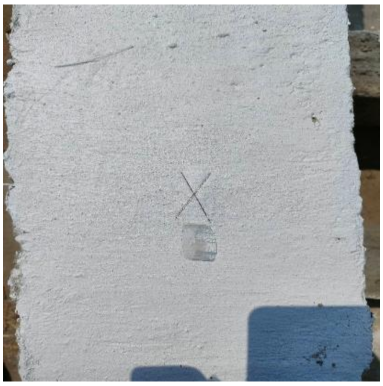
➢ *Adhesion Test*

Adhesion is rated based on the scale provided in the ASTM standard. The scale ranges from 0 "Removal beyond the area of the incisions" to 5A "No peeling or removal. Under Test Method A, an X-cut is made through the film to the substrate, and pressure-sensitive tape is applied over the cut and then removed. Test Method A primarily intends to be used in the field (*Corbet, 2020*). This test method is also known as the Cross Hatch test. (*Micom, 2021*)

Table 2 ASTM D 3359 Method A

Ratings	Evaluation Criteria
5A	No peeling or removal
4A	Trace peeling or removal along with incisions or at their intersection
3A	Jagged removal along incisions 1.6 mm (1/16 inch) on either side
2A	Jagged removal along most of the incisions up to 3.2 mm (⅛ inch) on either side
1A	Removal from most of the area of the X under the tape
0A	Removal beyond the area of the X

Table 3 Results of ASTM D 3359 Method A

Samples		Ratings	Evaluation
	Sample 1	5A	5A No peeling or removal
	Sample 2	5A	5A No peeling or removal
	Sample 3	5A	5A No peeling or removal
	Sample 4	5A	5A No peeling or removal

The adhesion test is carried out on the samples one week after the application of the banana fiber-induced paint. As a result, all samples have no peeling or removal with a rating of 5A.

The experiment used hollow blocks with a concrete fill plastered with a masonry potty coat to smooth the surface and improve its appearance before applying the banana fiber-induced paint.

CHAPTER IV
SUMMARY, CONCLUSION, AND RECOMMENDATIONS

- *Summary of Findings*

The study's findings were summarized according to the problem statement in Chapter I.

- *In terms of inside temperature, what impact does the ratio of the amount of banana fiber paint have on thermal resistivity?.*

✓ *0 Grams (Control)*
✓ *10 Grams*
✓ *15 Grams*
✓ *20 Grams*

According to the study, the banana fiber paint ratio considerably affects thermal resistance. It influences the temperature of four samples, even though the temperature decrease is not linear with the concentrations of pulverized banana fiber. When pulverized banana fiber is added to the paint, the temperature drops. The results from the study were also supported by the study of Assis et al. (2015), which indicates that banana fiber is a promising environmentally friendly insulator and could replace conventional synthetic materials. Indeed, things like car parts are already being fabricated with banana fiber-reinforced polymer composites since it yields a low thermal conductivity.

In a comparison of Banana Fiber Thermal Insulation with Conventional Building Thermal Insulation which is a study by Krishpersad Manohar and Anthony Ademola Adeyanju (2016), banana fiber also exhibited the characteristic behavior associated with fibrous thermal insulation of decreasing thermal conductivity with increasing density to a minimum value and then increasing in thermal conductivity with further increase in density which supports the results of the study that the temperature decrease is not linear and there is a certain amount and concentration of banana fiber that should be incorporated with other mixtures. In addition, the banana fiber showed the lowest thermal conductivity value of 0.04415 W/m.K. The thermal conductivity of banana fiber is within the range of building thermal insulation.

- *In terms of adhesion, what is the difference between regular elastomeric paint and elastomeric paint with different pulverized dried banana fibers concentrations?*

✓ *0 Grams (Control)*
✓ *10 Grams*
✓ *15 Grams*
✓ *20 Grams*

Four samples underwent the experiment: Sample 1, which is elastomeric white paint only; Sample 2, which has 10 grams of pulverized banana fiber mixed with elastomeric white paint, Sample 3, which has 15 grams of pulverized banana fiber and lastly, Sample 4 which has 20 grams of pulverized banana fiber concentrations.

Among the four samples tested under ASTM D 3359 Method A, Adhesive Test for Paintings, any amount of pulverized banana fiber mixed with elastomeric paint has no significant effect on adhesion. All of the samples received 5A ratings and evaluations.

It was supported by the study of Moon et al. (2012) that when elastomeric polyester paint undergoes an ASTM D 3359-09 or Adhesion Test, all samples with different concentrations have a rating of 5B, wherein no flaking is observed.

- *Conclusion*

The following conclusions were derived based on the summary of findings:

- The four samples were monitored for twenty-four (24) hours, presented by the researchers, and monitored again after three (3) weeks of application for four days. It was concluded that Sample 1 (paint only) had the highest temperature of all the samples every hour for 24 hours after one hour of application and still had the highest temperature for four consecutive days after three (3) weeks post-application of paint. On the other hand, it was concluded that Sample 4, with 20 grams of pulverized banana fiber concentrations, yields the lowest temperatures and has the most significant effect during the hottest time of the day for four days. In addition, according to the observations, it was clearly shown that the pulverized banana fiber has an effect in lowering the temperatures of the samples; even though the temperature results of the samples are not linear, it was clearly shown that the pulverized banana fiber is adequately a thermal-resistant additive. Moreover, according to the study's results, it was concluded that samples with pulverized banana fiber concentrations, in particular, Sample 4, have better thermal resistivity after three weeks post-application than after 1 hour of application.

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- According to the study, the ASTM D3359 or Adhesion Tape Test results have no variations. All Samples (1-4) performed well, having ratings of 5A or "No peeling or removal." It was concluded that the concentrations of the samples had no effect on the adhesivity of the paint since the samples only contained a small amount of powder.

➢ *Recommendations*

This study revealed the Thermal Resistivity of Pulverized Dried Banana Fiber on an External Wall. Thus, the following recommendations are hereby presented:

- Paint Centers should investigate the most effective method to grind banana fiber to smooth the wall surface while preserving the fiber's heat resistance.
- Future researchers interested in creating paint with thermal insulation could investigate and evaluate other popular thermal insulation materials, such as Mineral Wool, Fibreglass, Polystyrene, and Polyurethane, if appropriate and environmentally safe.
- Paint and coating companies should examine whether different paint colors were utilized to create banana fiber paint and whether those colors affect the fiber's ability to withstand heat.
- Future researchers should conduct the same research with a higher concentration of dried banana fiber to examine and see whether the paint with a higher concentration will produce the optimum outcome and if higher concentrations of pulverized banana fiber will significantly affect the adhesion test of the paint.
- Future researchers should examine the chemical, mechanical, and physical properties of the paint to determine why a specific concentration of paint and banana fiber behave that way and the relationship of concentrations of the samples to their properties.
- Future researchers who will conduct the same study should create a more homogenous cube made of cement to ensure data accuracy.
- The ability of samples of elastomeric paint to withstand water should be evaluated by subsequent researchers who will carry out the same study.

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DOCUMENTATIONS

➢ *Materials*



Banana Peel Banana Fiber Sodium Hydroxide

Soaking of Banana Fiber in 2 % NaOH Solution



Oven Drying Banana Fiber at 100° Celsius



Pulverized Banana Fiber

Thermal Resistivity and Adhesion Test Set-ups

Sample Readings in Mi Home App from Digital Thermometer