Republika ng Pilipinas
Lalawigan ng Marinduque
Bayang ng Mogpog
BARANGAY PUTING BUHANGIN

TANGGAPAN NG PUNONG BARANGAY

PAGPAPATUNAY

ALAMIN NG SINUMAN:

Ito ay pagpapatunay na ang mga pangalan sa ibaba, mga mag-aaral/estudyante sa Technological University of the Philippines-Cavite, ay lumapit sa barangay upang kumuha/humingi ng sample ng Pili Tree Sap dito sa nasasakupan ng Barangay Puting Buhangin, Mogpog, Marinduque.

Rechelyn R. Maling
Ma. Mikaela Masbate
Krezel O. Pinol
Luigi Aaron D. Suarez

Ang katunayang ito ay hiniling para sa anumang legal na pagkakagamitan.

Nilagdaan ngayong ika-16 ng Agosto, 2022 dito sa Barangay Puting Buhangin, Mogpog, Marinduque.

GILBERT P. MANUBA
Punong Barangay

Date: **July 27, 2022**

To: **IMELDA M. DIAZ**

OIC-PENR Officer

DENR-PENRO Marinduque

Capitol Compound Brgy. Bangbangalon

Boac, Marinduque

Re: **Request for Collection of Pili Tree and Antipolo Tree Bark for Research Purposes for Undergraduate Degree**

Greetings!

I am the adviser for the group of students for the undergraduate degree of Bachelor of Engineering Technology major in Civil Engineering Technology composed of Rachelyn Maling, Ma, Mikaela Masbate, Krezel Pinol, and Luigi Aaron Suarez. They are currently working on a research project entitled "Development of Binder for Single-layer Particle Board Using Antipolo Tree Sap and Pili Tree Sap with Pulverized Charcoal."

In connection with this, I would like to recommend these students and kindly request your good office for them to be allowed to collect Antipolo and Pili Tree Sap in Marinduque as a primary material for their research project. These materials will significantly help the following students to complete their research projects and complete the requirement for the program.

Your favorable response to this request is highly appreciated. Thank you very much.

Very truly yours,

Joshua Nikko Malicsi

Research Adviser

DEVELOPMENT OF BINDER FOR PARTICLEBOARD USING ANTIPOLO TREE SAP AND PILI TREE SAP WITH PULVERIZED CHARCOAL

A Research Project

Presented to the faculty of the
Department of Industrial Technology
Technological University of the Philippines Cavite Campus
C.Q.T Ave. Salawag, Dasmariñas City, Cavite

By:

Maling, Rechelyn R.
Masbate, Ma. Mikaela
Pinol, Krezel O.
Suarez, Luigi Aaron D.

In Partial Fulfillment of the Requirements for the Degree
Bachelor of Engineering Technology major in Civil Technology

revised after proposal defense
07-11-2022

July 2022

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INTRODUCTION

Background of the Study

The more significant part of particleboards is formaldehyde-based, mainly urea-formaldehyde resin (UF). Formaldehyde could be a chemical compound classified as a human carcinogen. Bio adhesives showcase is generally little due to the taking a toll on crude materials and their lower execution.

Glues came from plants, animal parts, or oil-based chemicals. Produce a binder at home by mixing water and wheat flour. Researchers will only use natural materials to create an eco-friendly binder in developing particleboard binders.

This study aims to have an alternative method of creating wood binder that uses natural materials (Pili and Antipolo tree) rather than dangerous chemical products. The results of this study will be beneficial for small business owners or corporations that manufacture particleboards.

Formaldehyde was classified as a carcinogenic compound by the World Health Organization (WHO) International Agency for Research on Cancer (IARC) in 2004. The main formaldehyde compounds are utilized in furniture, plywood, and particleboard fabrication.

Woodworking adhesives range from water-based, non-toxic polyvinyl acetate emulsion glues to hazardous resorcinol formaldehyde resins. High material and labor costs in carpentry contribute to environmental issues. Wood glues are non-flammable and release relatively few emissions.

Fabricate a particle board binder using natural materials. Pili tree sap, Antipolo tree sap, and pulverized charcoal will adopt for the binder. This binder will thicken the mix like corn starch in every liquid mixture.

Objectives of the study

The general objective of this study is to develop a binder using Antipolo tree sap and Pili tree sap with pulverized charcoal for particleboard.

Specifically, the study aims to:

1. Formulate a natural wood binder using Antipolo tree sap and Pili tree sap with pulverized charcoal.
2. Fabricate the particleboard using Antipolo tree sap and pili tree sap with pulverized charcoal as natural binder.
3. Determine the particleboards' physical and mechanical properties using ASTM standards.
4. Compare the Physical and Mechanical properties of fabricated particleboard with the commercial particleboard.
5. Evaluate the acceptability of the output using the evaluation form in terms of functionality, aesthetics, durability, economy, and safety.

Scope and Limitations of the study

The main focus of this study is to create a wood binder made from natural materials such as Pili tree sap and Antipolo tree sap with Pulverized charcoal. The study involves the development of a binder using raw materials, using the fluid from the Pili tree and Antipolo tree, including the pulverized charcoal to be applied in particleboard. Mixtures of natural materials are 20 percent, 40 percent, and 60 Percent mixture of Pili Tree sap and Antipolo tree sap, respectively. Rdhan Residential Building construction will benefit this research project after approval. This research project is limited only to ASTM D1037, ASTM D1037-99 Moisture content, ASTM D570 water absorption, ASTM D3502-76 (ASTM 1999) thickness, swelling, density, modulus of rapture and modulus of elasticity, face screw holding, and Nail-head pull-through.

Significance of the study

To achieve sufficient reactivity and adhesive efficacy, all adhesives on the market use fossil-based components, and many contain formaldehyde. People increasingly depend on bonded wood items for construction, furniture, and flooring. As public environmental consciousness grows, it becomes clear that greener, more sustainable options are essential. The researchers aim to contribute to the fraction of putting an alternative source of natural ingredients in the binder for particleboard.

Chapter 2

CONCEPTUAL FRAMEWORK

This chapter consists of 3 parts, Review of Related Literature and Studies, Design Thinking Process which explains the Empathize, define, ideate, experimental, and testing of the study with Operational Definition of terms.

Review of Related Literature

Wood binder

Epoxies are hardeners and solvents found on store shelves as epoxy or epoxy resin. Acetone, methyl ethyl ketone, toluene, xylene, glycol ethers, and alcohols often used as BPA is present in several epoxy resins. Also, polyurethanes employ in various products, including furnishing flexible foam, adhesives, sealants, and glues. Toluene diisocyanate (TDI) and methylene diphenyl diisocyanate are two of the many compounds in polyurethanes (MDI). MDI is also used to bind composite wood products such as particleboard, fiberboard, and oriented strand board (OSB). In addition, benzene and formaldehyde are used to manufacture glues. The glues and adhesives used to make pressed wood (composite wood) items frequently contain formaldehyde. Adhesives frequently contain phthalates and formaldehyde. As a result of these chemicals, they may play a role in asthma, developmental problems, cancer, and autoimmune disorders. Chlorine, toluene, formaldehyde, benzene, and other chemicals used to manufacture TDI, and MDI are all members of the Volatile Organic Compound (VOC) family and have been linked to both short and long-term health consequences. Not only have leukemia, breast, lymphatic, and hematological malignancies been related to these substances, but they may also cause chromosomal (cell) damage and impact the nervous and developmental systems. In

addition, these compounds emit gasses, resulting in poor indoor air quality. They could cause liver and kidney damage, birth abnormalities, allergies, asthma, and cancer. (Carl A. Eckelman, n. d.)

For this reason, the purpose is to present an alternative technique of making glue that employs natural materials (Pili and Antipolo trees) instead of hazardous chemical items. This glue will benefit those in the carpentry sector concerned about toxins, and it is also simple to put together in times of financial trouble. The potential of the Pili and Antipolo trees as a renewable resource for several uses is a highlight. Furthermore, this focuses on creating a new glue made from the sap of the Pili and Antipolo trees. A person who could not afford to buy it would benefit from the consequences. The Pili and Antipolo trees could potentially be employed by the impoverished to boost their productivity and income. It would also provide further information on the potential of the sample plants. (Sarah Lott et al., 2013)

The performance of a wood adhesive manufactured from pili sap and coconut lumber sawdust utilizing a tensile pressure test with various weights on wood blocks measuring 1 x 1.5 x 2 inches. Use glue proportions to bind two blocks on a face with a surface area of 3 sq. inches. The spread rate was 2.5 mL/sq. Recorded inch and the highest weight the bordered blocks could withstand. A survey of 15 randomly selected population members of the construction working group will conduct for supplementary data. The same types of samples were used. The criteria for an effective adhesive were based on a Likert scale, which included standards based on the attributes of an effective glue. Set-Up A had 25 percent Pili sap and 75 percent Coconut Lumber sawdust; Set-Up B had 50 percent Pili sap and 50 percent Coconut Lumber sawdust, and Set-Up C had 75 percent Pili sap and 25

percent Coconut Lumber sawdust. A commercial wood adhesive was used as a check to ensure that the proportions were correct. (Princesa et al., 2015)

Tree sap

Xylem and phloem are two different fluids that are frequently bundled together under the term sap. In a long string formation, the xylem distributes water, minerals, and hormones from the bottom to the top of the tree. Every year, the xylem channels die, and new ones emerge. When you cut down a tree and see those beautiful rings, you're looking at the old xylem channels, one for each year of existence. Phloem, on the other hand, is the sticky, sugary substance with which we frequently come into touch, whether by accident or on purpose. It was made of sugars produced by photosynthesis, which are subsequently given back into the tree as much-needed food throughout the growing season. Pine tree sap is an antibacterial, anti-inflammatory, and astringent that effectively heals and bandages wounds. Pine sap can waterproof seams in boots, boats, and shipping containers. One of the best juices to consume is birch tree sap or water. Birch offers remarkable healing capabilities and detoxifying effects. Unnatural blistering or oozing of sap on trees can generate various factors, including disease, fungus, or pests. On the other hand, trees rarely leak sap unless they are harmful in some way. According to Guinness World Records, the manchineel tree is the deadliest tree on the planet. It produces a viscous, milky sap that seeps from the bark, leaves, and fruit. This sap contains a variety of poisons, but it is considered that phorbol causes the most severe symptoms. Carpenters use the wood for furniture after drying it in the sun to kill the toxic sap. (Fergus Masons, n. d.)

Mixture

Four (4) parts sap, 1 part charcoal, and 1 part rabbit droppings are the used ratio. If you like, you can make some changes. Your hot liquid glue is now ready. As it cools, break it up into little pieces for storage. You can create a string out of it or store portions of it; reheat your pitch pine glue over a flame when ready to use it, and presto! This is a great glue that will harden and last after it cools. (Survival Manual, n.d.)

Particleboard adhesive

Moreover, (Nicolas Brosse, 2020) stated that using previously published tannin-based resins and wood particles (Fagus sylvatica and Picea Abies) at 3.43 MPa with maximum pressure and 190-195 °C press temperature, one layer of 350 300 16 mm3 particleboards was created in triplicate [20]. Based on dry wood, the sticky resin had a 10% content. It took 7.5 minutes to push everything. The dry internal bond (IB) strength test, an important international standard, is performed on the particleboards (EN 312).

Production Process of Particleboard

Particleboard is a non-structural panel used in manufacturing furniture, cabinets, tables, countertops, and millwork, as well as an underlayment in home construction. It came from the wood residue, including shavings, sawdust, fines, and chips, as well as urea-formaldehyde resin, catalyst, wax, and scavenger. The production process for particleboard is fully automated, method operated, and comparatively linear. The wood residue is then sorted and stored, with the wood will screen to ensure it passes through a set of screens that sort it by size. The wood residue will refine, a mechanical process that reduces the geometry of the residue into uniform sizes with desired dimensions. The particles will dry in dryers, usually rotary dryers with a single or triple pass configuration. The mixture of

resin, wax, catalyst and scavengers will be distributed onto the particles as discrete droplets. The composite particles will spread into a flat mat in multiple layers of three or five consisting of the face and core layers—the particle size, moisture, and resin content are all controlled for the face and core layers to achieve the desired panel properties. The shaped materials will move into large presses, most of which are stack presses with multiple openings. Presses must operate at sufficient temperature and duration to cure the resin and at as well as at adequate pressure. Hot panels exiting the press are placed on a cooling wheel, allowing the panels' temperature to drop below the point at which the UF resin begins to degrade and emit formaldehyde gas. Boards will polish to the desired thickness and smoothness on both major surfaces. Large panels will be cut to panel widths of 4 or 5 feet and lengths of 8 or 9 feet or even longer. (James Wilson, 2018)

Development of Particleboard

Creating innovative particleboard (chipboard) panels for improved mechanical performance and more negligible environmental effect is one of the objectives of a collaborative European initiative named DIPP. Hemp, sunflower, Jerusalem artichoke, maize, and miscanthus are some annual and perennial agricultural plants used to make lightweight particleboard. These thin particleboards are meant to be a potential replacement for the heavier particleboards typically made of wood and used in the furniture sector. Consequently, the EN 312 standards for the Boards used inside must have the necessary mechanical and moisture-related qualities. The study's findings demonstrated that although three-layer boards containing Jerusalem artichoke in the core layer did not fulfill these standards, one-layer lightweight particleboards developed in the experiment did exceed the

requirements of EN 312 (type P2). The low-weight boards did not satisfy the bending strength and elastic modulus criteria. (Balducci, Francesco, et al., 2008)

In formulating particleboard, formaldehyde-based resins as binders will use. According to epidemiological studies, formaldehyde is carcinogenic. To eliminate the health risks associated with formaldehyde-based resin in particle board formulation, they included using formaldehyde scavengers and an alternative binder. The cost and maintenance of particleboard formulations that use formaldehyde scavengers are increasing. There is also no evidence that the scavengers reduce particleboard formaldehyde emissions. Using biobased binders in particleboard formulation eliminates the need for formaldehyde-based resin. (Kariuki, Stephen Warui et. Al., 2019)

Binder for Particleboard

The bulk of adhesives used nowadays in particleboards (PB) production is formaldehyde-based. The current study examined a low-cost bioadhesive for three-layer particleboards produced under different manufacturing settings using thick wasted sulfite liquor (TSSL) and wheat flour (particleboards target density, pressing time, pressing temperature, wood type, and binder age). Particleboards may be made with thicknesses ranging from 682 kg/m3 to 783 kg/m3, encouraging periods of 8 to 10 minutes and temperatures between 180 and 210 °C. Particleboards of type P2 (0.35 N mm2) manufactured under these circumstances all met the internal bond strength criteria of standard EN 312. For particleboards pressed with the recycled wood mixture for 10 minutes at 200 °C, the best result (0.69 0.01) N mm2 was attained. Particleboards made with binder demonstrated good internal bond strength ((0.58 0.02) N mm2) in terms of

resin stability, surpassing the requirements of standard EN 312 for P2 particleboards. (A.M. Ferreira et al., 2019)

Review of related studies

Wood binder

Composite wood, made up of a mixture of adhesives and wood particles, highly depends on bonds. The glue is usually used to secure furniture attached with wood dowels. Even screw-secured furniture joints may include glue. Ancient Egyptians knew how to veneer and use adhesives to adhere ornaments to the table; therefore, adhesive understanding and application are not new concepts. For thousands of years, mud, manure, and clay, among other things, have been used to make adhesives. (Carl A. Eckelman, n. d.)

Particle board

Particle board is a waste product from a combination of sawdust and glue. It can swell and become unstable when exposed to water, even though it won't bow or warp like plywood. Furniture, underlayment, and countertop substrate are the most common applications. All power tools can mill it, and it has modest tear-out. The most prevalent finishes are laminate and veneer. Particle boards are available in 4-by-8-foot panels, and 1/2-inch to 1-inch-thick pre-cut shelf boards are available in various sizes. (Brian G., 2020)

Sap with charcoal

Furthermore, Particleboard is a type of flooring used to cover hardwood floors. It protects the hardwood boards from scratches and temporary construction flooring built with particle boards. It is appropriate as a foundation or underlayment for wood, parquet, and carpeting. This board was used to construct the core of flush and solid core doors. Particleboard is a good door core material because it has a smooth and flat surface that

quickly bonds with the door skin and has a good screw holding capacity for hinges. False ceilings are also made from this type of board because particle boards provide excellent thermal insulation. They also serve as ceiling tiles in a variety of structures. Particle boards make everything from dressing tables to tabletops to kitchen cabinets, wardrobes, bookcases, shoe racks, and mattresses. Particle boards are used to drive speakers because they absorb sound. Particle boards are also applied to the walls and floors of recording studios, auditoriums, and media rooms. (Team McCoy Mart, 2022)

Pitch glue is made from sap and is a strong adhesive. Native Americans used pitch glue made from natural materials to create tools and waterproof items. Pitch glue is different from traditional glue available in stores today because of its tar-like consistency and high malleability. While other tribes have recipes for making asphalt gum and adding or subtracting ingredients to make it fibrous, no single method can achieve effective results. (Rose Kivi, 2019)

The enacted charcoal has a quickening impact on the curing of the UF gum. The Crosslink thickness of tar increments, and the actuation vitality diminishes. The effect of the actuated charcoal expansion was especially famous in medium-density fiberboard. The enacted charcoal has a quickening impact on the curing of the UF gum. The Crosslink thickness of tar increments, and the actuation vitality diminishes. The effect of the actuated charcoal expansion was especially famous in medium thickness fiberboard by the increment within the esteem of modulus of crack and inner bond quality of the board, a coordinate sign of the execution enhancement with the expansion of a little sum of enacted charcoal. The formaldehyde emanation altogether diminishes with the development of activated charcoal. (A. Kumar et al., 2013)

According to L. Louder et al. (2019), The sticky and waterproof characteristics of resin, a natural secretion of many conifers, have been used by Indigenous peoples of British Columbia for hundreds of years to strengthen and waterproof their tools, watercraft, and houses. The adhesive strengths of unpurified pine resin and a 50:50 combination of pine resin and beeswax on wood surfaces were investigated in this study. The researchers compared the adhesive properties of pine resin and commercially available glues to see if they might be used as a natural alternative. Elmer's all-purpose craft glue, fish glue, and hot glue from a glue gun were all compared for their sticky properties. The pine resin was projected to have substantial adhesive strength comparable to certain commercial bonds, and it was shown to have a mean adhesive strength statistically like commercially produced fish glue, but not Elmer's glue or glue from a glue gun. The mean forces of separation for the adhesives, on the other hand, had substantial standard deviations, indicating that Elmer's glue and pine resin are likely similar. This suggests that pine resin could be used as an alternative to chemical-based glues and commercially available fish glue for occasional use on wood surfaces.

Particleboard

The particle board and MDF business have grown to become our country's primary source of raw materials for the furniture industry. Furniture makers in our country have begun to employ chipboard and MDF for furniture production since they are less expensive and easier to obtain than solid materials. In this study, a qualitative research method was used to interview 20 small and medium-sized furniture and decoration businesses in the provinces of Bolu and Mudurnu. The research employed a semi-structured interview method, with content analysis on the documents following the interview. The content

analysis highlighted the most common plate-based and socio-economic problems. Density, dimensional change, and surface issues were among the board-related issues, while costs and suppliers were among the socio-economic issues. Furniture producers have expressed their dissatisfaction with low density and expensive pricing. The firms have been determined to be reliant on the dealers and unable to go beyond what the dealers offer them regarding plate preference. Furthermore, it was determined that the dealers did not take the complaints seriously and were desperate for a solution to their difficulties. (Koksal et al., 2022)

According to Kinjal Mistry (2017), Particle boards have the advantage of being less expensive than plywood or medium-density fiberboards. Laminated particle boards and veneered particle boards, when compared to plywood, provide decorative aesthetics at a reduced cost. It creates a smooth, flat surface to which decorative laminates or wood veneer can be applied. This particle board is more resistant to wear and tear and more pleasing to the eye. As a result, laminated and veneered particle boards are now often used in office furniture production. It is difficult to dent or distort. Because of their negligible weight, particle boards may be easily moved and handled. Particle board is widely used to make furniture constructed with screws since it can hold more screws than MDF. It requires little maintenance and is easy to clean. Particle boards provide excellent thermal and acoustic insulation, making them perfect for use in auditoriums and theaters as speakers and fake ceilings. Because it is created from wood waste such as wood chips, sawdust, wooden shavings, and bagasse, which is the sugarcane residue after the juice has been taken, it is an environmentally friendly item.

However, According to Kinjal Mistry (2017), when compared to other fiberboards, particle boards have low strength. Because of its low density, it is readily destroyed during shipping. The particle board swells and warps when exposed to dampness. Discoloration can also occur in extreme settings. Compared to medium-density fiberboard and plywood, particle boards have lower durability and longevity due to their low strength and susceptibility to moisture damage. Because of its frailty, it is unable to support considerable loads. Particle boards are dangerous because they are made with urea-formaldehyde resin that emits formaldehyde gas. Even after years of use, the resin can degrade and generate formaldehyde gas, which is toxic in humans and can cause cancer. Particle board furniture can be used in various ways in the home's interior. Although particle board has a low strength, it also has a low-price tag. After weighing the benefits and drawbacks of particle board, the homeowner should make a selection based on his needs and budget.

Many studies on the properties of particleboard have been conducted. Wu, for example, made particleboard from hammer mill bagasse. Two adhesive contents (polymeric methylene diphenyl diisocyanates 5% and 8%) and two density levels (0.72 and 0.88 g/cm3) were combined in this study. Performance characteristics of the particleboard were assessed, including linear expansion, hardness, elasticity and rupture modulus, internal bond strength, and thickness swelling. As stated by the author, increasing the level of resin content achieved higher power and minor swelling in general. Nacar and colleagues investigated eucalyptus particleboard's physical and mechanical properties (Eucalyptus camaldulensis). It discovered that the bending properties of samples manufactured with two levels of density and adhesive content (7 and 8 percent urea-formaldehyde (UF)) were considerably different. They postulated that improving

mechanical qualities would result from increasing particleboard density, press time, and adhesive content. Moreover, agricultural residues have been used because of recent interest in environmentally friendly materials as a raw material to produce particleboard like coconut chips, bagasse, and waste tea leaves. Additionally, coffee husks and hulls can be used to make value-added products such as particleboard or building insulation. Coffee brewing waste is a significant contributor too. Since coffee is a popular beverage, approximately 1 billion cups of coffee are consumed worldwide daily. As a result, waste from coffee has left to dry for 6 hours in a hot-air dryer at 105 degrees Celsius. After drying, the coffee waste's moisture content was around 8%, sieved using a 20-mesh size. The MOR and MOE also climbed as the resin concentration increased. The MOR and MOE significantly increased for coffee waste boards when the adhesive fraction increased from 11% to 25%. Higher sticky concentration levels resulted in improved mechanical capabilities. After that, the coffee waste was mixed with UF or PDMI (11 percent, 14.5 percent, 18 percent, and 25 percent) and shaped into a mat measuring 160 mm by 160 mm inside a stainless-steel frame 6 mm thick. Hot compression was used to press the mat at 140°C for 7 and 8 minutes, respectively, using two pressure levels (44.48 and 66.72 kN), and it took 8 minutes for the mat to drop to room temperature. This research's MOR and MOE results are broadly like those from past studies. PMDI-bonded particleboard has a higher MOR and MOE than UF-bonded particleboard. This research is comparable to that of Bekalo and Reinhardt, who produced particleboard from the husks and hulls of coffee beans. The bonding process with UF resin was less effective than with PMDI resin due to the changes in mechanical characteristics. Additionally, similar to the pattern found with

conventional particleboards, the MOR value of the particleboards rose as board density increased. (Nisachon Ketsamak, 2012)

Particleboard adhesive

Water Extraction of Tannins from Aleppo Pine Bark and Sumac Root for the Production of Green-Wood Adhesives the development of environmentally friendly wood adhesives has been an active research area for many years. Tannin-based adhesives have been successfully used as binders for particleboard panels. Tannins can be divided into two main groups: condensed and hydrolyzable tannins. Condensed tannins are mainly used for adhesive applications, composed of flavonoid units with varying degrees of polymerization. The different tannin-based adhesive formulations were used to press one-layer wood particleboards. The internal bond of the panels was found to be a good indicator of the adhesive's performance. The discussions appeared to have good inner bonding strengths with the four hardeners, meeting relevant international standards for interior-grade panels. The results of the current experiment were generally consistent with those of a previous TMA experiment. (Dababi et al., 2020)

Using green adhesives to reduce the health threat related to formaldehyde-based particleboard is good. Using natural adhesives has helped lessen the impending health challenges and construction costs. (O. H. Hussin et al., 2020).

Table 1.

Requirements for grades of particleboard

Grade	MOR MPa	MOE MPa	Internal bond MPa	Hardness N	Linear expansion max avg (%)	Screw-holding		Form-aldehyde maximum emission (ppm)
						Face N	Edge N	
H-1	16.5	2,400	0.9	2,225	NS[d]	1,800	1,325	0.3
H-2	20.5	2,400	0.9	4,450	NS	1,900	1,550	0.3
H-3	23.5	2,750	1	6,675	NS	2,000	1,550	0.3
M-1	11	1,725	0.4	2,225	0.35	NS	NS	0.3
M-S	12.5	1,900	0.4	2,225	0.35	900	800	0.3
M-2	14.5	2,250	0.45	2,225	0.35	1,000	900	0.3
M-3	16.5	2,750	0.55	2,225	0.35	1,100	1,000	0.3
LD-1	3	550	0.1	NS	0.35	400	NS	0.3
LD-2	5	1,025	0.15	NS	0.35	550	NS	0.3

Source: ANSI A208.1-1993 (National Particleboard Association, 1993). National Particleboard Association, Particleboard, ANSI A 208.1-1993, American National Standards Institute, Gaithersberg, MD, 1993

Table 2

Requirements for Grades for Particleboard Flooring Products

Grade	**MOR MPa**	**MOE MPa**	**Internal bond MPa**	**Hardness N**	**Linear expansion max avg (%)**	**Form aldehyde max emission (ppm)**
PBU	11	1,725	0.4	2,225	0.35	0.2
D-2	16.5	2,750	0.55	2,225	0.3	0.2
D-3	19.5	3,100	0.55	2,225	0.3	0.2

Source: ANSI A208.1-1993 (National Particleboard Association, 1993). National Particleboard Association, Particleboard, ANSI A 208.1-1993, American National Standards Institute, Gaithersberg, MD, 1993

Conceptual Framework

This section provides the study's conceptual model, which represents the study's emphatize, define, ideate, experimental, and testing.

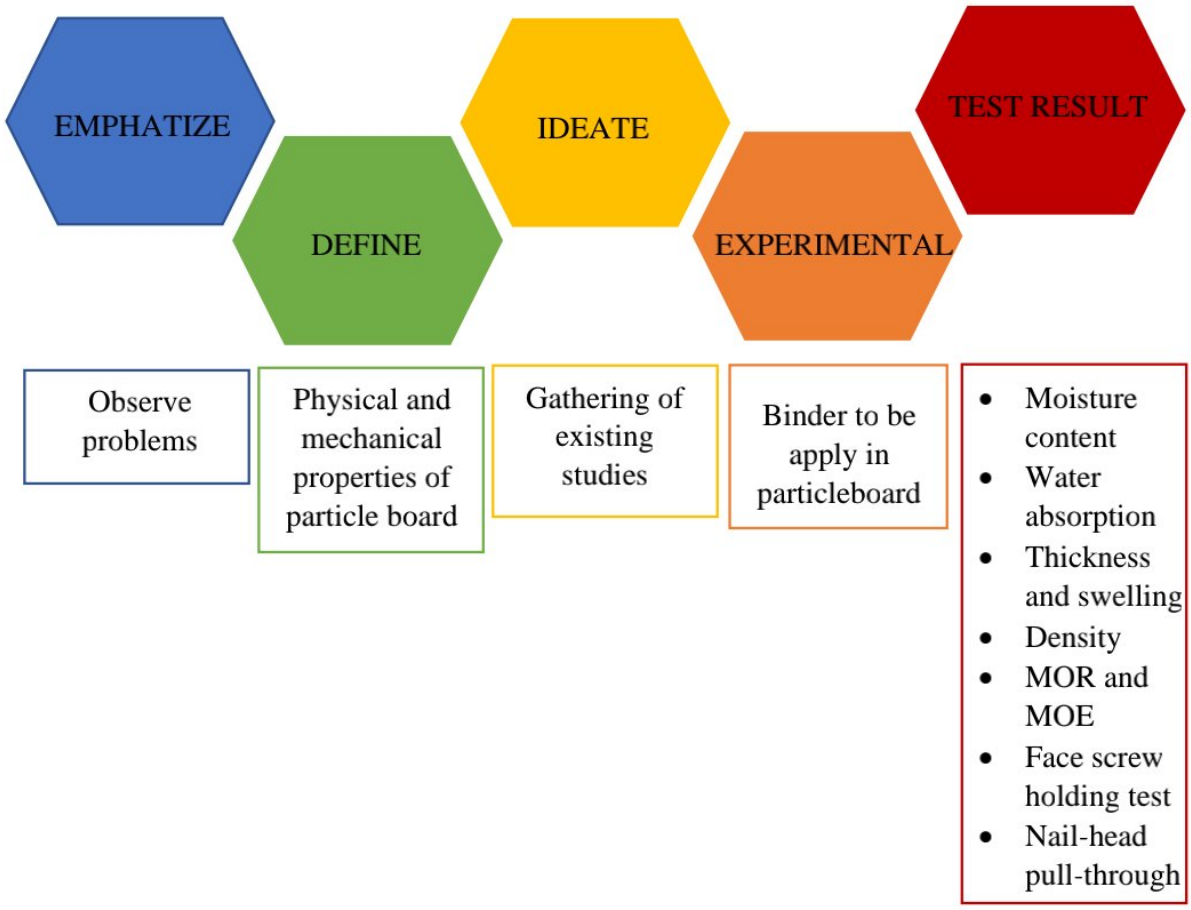

Figure 1 Design thinking process

Observe problems in wood binders that use harmful chemicals. Define the physical and mechanical properties of particleboard using ASTM standard testing. Gathering information from the existing studies will help this study to be more effective.

Development of Binder for Particleboard using Antipolo Tree Sap and Pili Tree Sap with Pulverized charcoal will be the output of this study, then test of the product using ASTM standards which are moisture content, water absorption, thickness and swelling, density modulus of rupture and modulus of elasticity, face screw - holding strength and Nail-head.

The gathered information from the previous study found that the combination of sap and charcoal are effective in production of particleboards.

The methodology of this study starts from gathering of materials followed by mix proportion then applying the mixed binder in 30x30 cm and 12.7 cm thick particleboard. The sap and charcoal ratio are 1:4. Also, 25 percentage of binder per specimen.

Fabricate particleboard with different mixture of sap and charcoal with 140ºC in hot compression then cool in room temperature for 8 minutes. All this process must be done in all mix design, a total of 3 specimen then cut into specific sizes for different testing. The simple testing includes moisture content, water absorption, thickness and swelling, density, modulus of rupture and modulus of elasticity, face screw holding test and Nail-head pull-through. The evaluation will begin after the ASTM standard testing.

Operational Definition of Terms

Adhesive a substance (such as glue, starch, paste, or mucilage) that adheres to the surfaces of two materials to form a bond.

Antipolo Tree is a huge tree with a habit, size, and leaf appearance comparable to breadfruit.

ASTM American Society for testing and materials - is a non-profit organization that creates and publishes voluntary consensus technical standards for a variety of materials, goods, systems, and services.

ASTM D1037 provides several test techniques and specifications for determining the characteristics of wood-based fiber and particle panel materials.

Artocarpus is a genus of about 60 trees and shrubs native to Southeast Asia and the Pacific, belonging to the Moraceae family of mulberries.

Aspen wood is a common name for several tree species; some, but not all, are designated by botanists as belonging to the Populus genus section Populus.

Binder anything utilized in the binding process.

Bio adhesive These are adhesives made from natural polymeric ingredients.

Conarium ovatum is the Philippines' most important nut-producing species. Despite being one of the more typhoon-resistant species, catastrophic typhoons have wreaked havoc on pili trees.

Ellipsoid is a surface that can be created by deforming a sphere using directional scaling or, more broadly, an affine transformation.

Formaldehyde Particleboard, plywood, and other pressed-wood goods include is a colorless, strong-smelling, combustible chemical that is manufactured industrially

and used in construction materials such as particleboard, plywood, and other pressed-wood products.

Glue used as an adhesive in a solution, or any sticky adhesive ingredient.

International agency for Research on Cancer (IARC) The International Agency for Cancer Research is an international organization that is a component of the World Health Organization of the United Nations. Its goal is to carry out and coordinate cancer research.

Medium density fiberboard (MDF) is a composite material made of fibers from recycled wood and resin.

Moraceae The fig family, often known as the mulberry family, is a flowering plant family with about 1100 species and 38 genera.

Pili tree Canarium ovatum is a burseraceous Philippine tree with tasty almond-like seeds.

Particleboard is made from wood components that have been heated and pressure glued together using an adhesive.

Phenol formaldehyde resin (PF) or phenolic resins Synthetic polymers made from the reaction of phenol or substituted phenol with formaldehyde are known as phenoplasts.

Pitch Glue it is a viscoelastic polymer generated from petroleum, coal tar, or plants that may be natural or synthetic.

Pulverized charcoal is a kind of raw material. It's charcoal in the form of dust.

Resin it is a general name for a polymer, a polymer precursor material, and/or a combination or formulation of these materials including different additions or chemically reactive components.

Tree sap Sugars are produced because of photosynthesis and are given back into the tree as food throughout its growth stage.

Urea-formaldehyde (UF) A non-transparent thermosetting resin or polymer, commonly known as urea-methanal, is called by its common manufacturing method and overall structure.

Wettability refers to a liquid's ability to retain contact with a solid surface, and it's determined by the intermolecular interactions of the adhesive (liquid to the surface) and cohesive types of molecules (liquid to liquid).

Wood the tough, fibrous material makes up a tree or shrub's trunk or branches and used as wood or fuel.

Wood binder The manufactured wood products sector is dominated by two forms of glue, or binders as they are known in the industry.

Wood extractives often known as wood extracts, are small compounds extracted from wood using solvents or other processes.

World health organization (WHO) WHO's principal responsibility is to lead partners in global health responses and to direct international health within the UN system.

Chapter 3
RESEARCH METHODOLOGY

This chapter presents the method of a research study. It includes project design, project development, operation and testing procedure, and the evaluation procedure.

Project design

The experimental design for this study, titled "Development of binder for particleboard utilizing Antipolo tree sap and pili tree sap with crushed charcoal," was based on data gathered from a review of related literature. The approach is necessary to fulfill the study's aims. A mixed percentage will use when placing a wood sample in the experimental program. MD1 is a 20 percent pili, 60 percent Antipolo replacement ratio for the experiment. MD2 consists of 40 percent pili and 40 percent Antipolo. MD3 is 60 percent pili and 20 percent Antipolo. The part of the charcoal will be 20 percent for each set of the mixture since the mixture of two sap variables equals 1000 grams.

The mix design will adopt the adhesive property of the combined pili (Canarium ovatum) sap and coconut (Cocos Nucifera) lumber sawdust as tested on wood blocks. Fabricate 30 x 30 centimeter and 12.7 cm thick particleboard, a total of 3 specimens per mixture, then cut into specific sizes for testing.

ASTM D1037 – 99 Standard Test Method for Evaluating Properties of Wood-Base Fibre and Particle Panel Materials. ASTM D570 standard - to determine water absorption rate by immersing the specimen in water for a specific period. According to ASTM D 3502-76 (ASTM 1999), two tests—water immersion and change in relative humidity, namely between 10 and 90 percent—are used to assess the thickness swelling and density.

Also, the Modulus of rapture and modulus of elasticity, face screw holding test and Nail-head pull-through will be conducted.

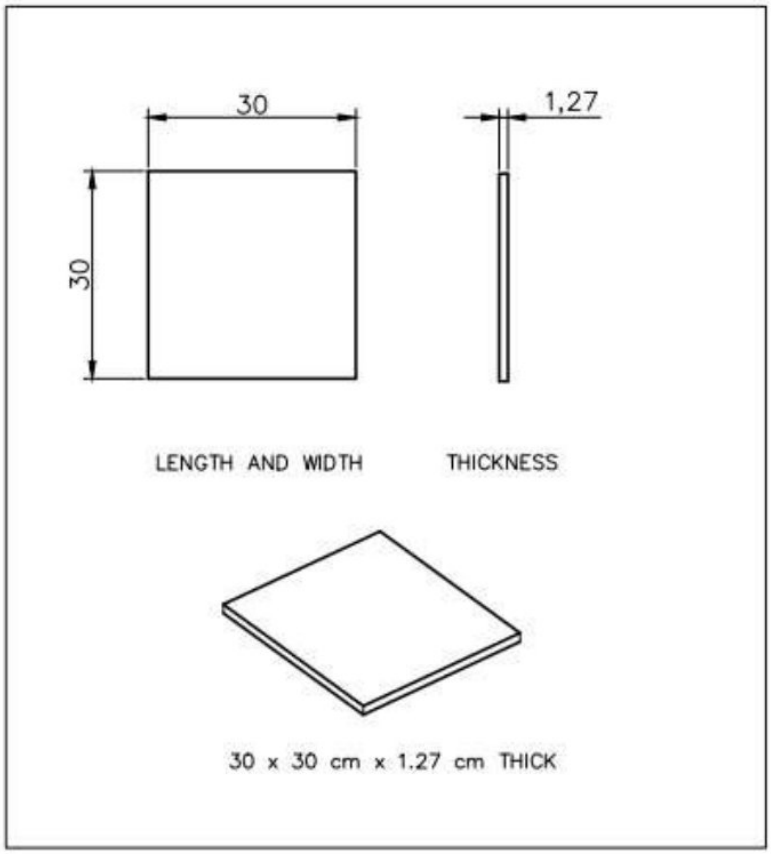

Figure 2. Particleboard

Figure 2 illustrates the Orthographic and isometric drawing of particleboard. 30 cm wide, 30 cm long and 1.27 cm thick, cut into specific sizes for testing.

Project Development

This section covers the detailed procedure of this experimental study. All the actions in this study will be illustrated in the flowchart below. The Antipolo Tree Sap and Pili Tree Sap with Pulverized Charcoal Binder for Particle Board will develop using the following steps.

Flowchart

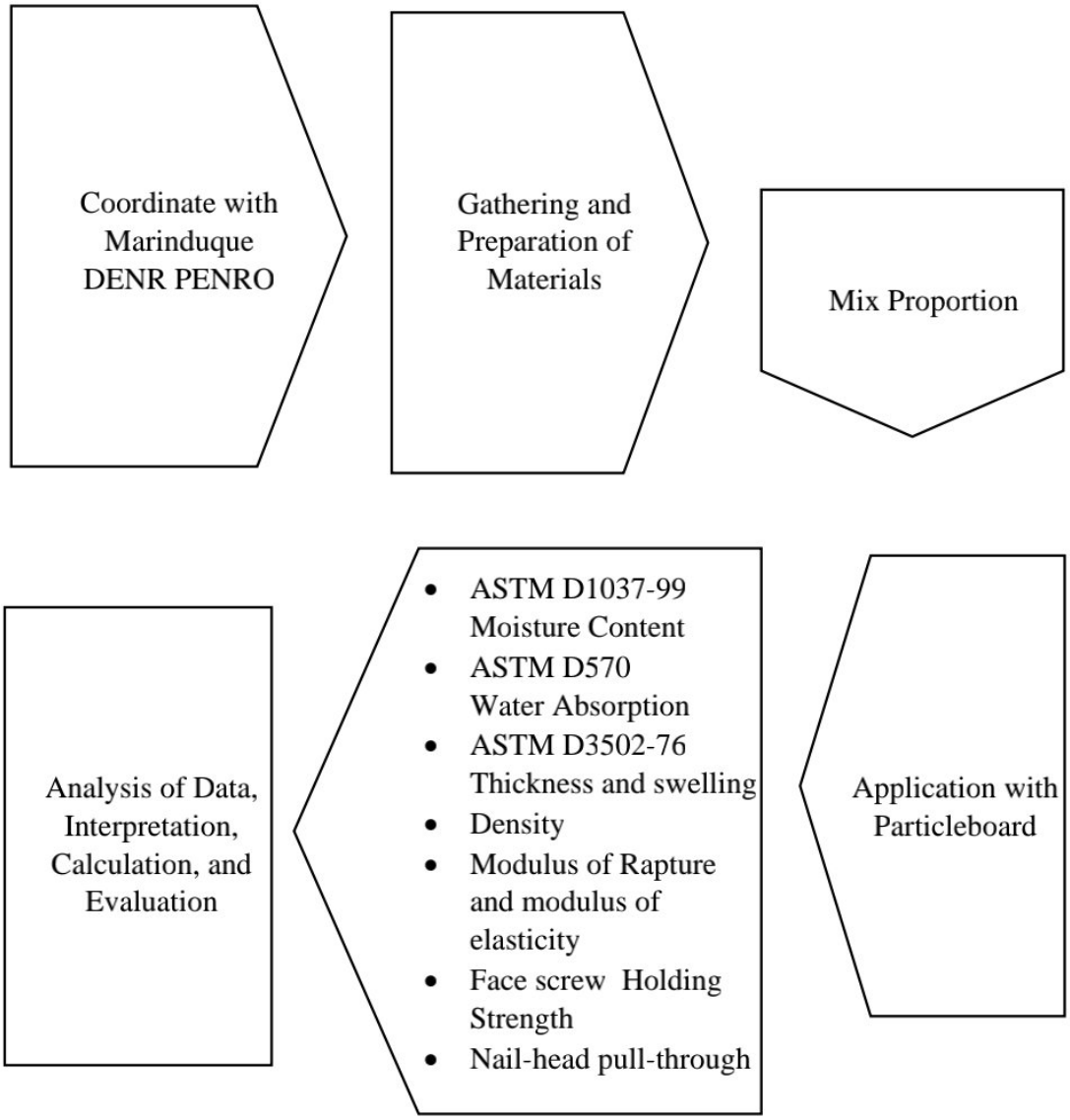

Figure 3 Research Paradigm of Study

Figure 3 illustrates the paradigm of the study. It starts with coordinate with Marinduque DENR PENRO then gathering and the preparation of materials for the study, next step id mix proportion then application with particleboard followed by testing and ends with the analysis of data, interpretation, calculations and evaluation after the conduct of the various processes and test to the specimen.

1. Coordinate with DENR PENRO – Marinduque

Send the request letter personally to the DENR PENRO - Marinduque. Wait for the approval of the authorized personnel of DENR PENRO for the schedule of assistance in gathering data about the materials needed for this project.

2. Gathering and preparation of materials

All materials needed are Pili and Antipolo sap, pulverized charcoal, a clean container, weighing scales, a measuring container, mixing sticks, and wood chips that will collect from the forest of Marinduque, Philippines.

2.1 Tree sap

Pili tree sap and Antipolo tree sap are utilized for this particular study. The gathering of tree sap will take 14 to 21 days to collect 1 gallon or 3.78 liters. The size of the hole in the trees will be one and ½ inches wide. The materials and types of equipment used by the researchers were a bowl, weighing scale, stirring rod, and empty containers.

Figure 4. Gathering of Sap
Source: http://surl.li/cjesg

Figure 4 represents the process of gathering sap using a clean container, bowl, and 1 ½-inch wide hole

2.2 Charcoal

Purchase charcoal. The charcoal will be crushed using hammer to be pulverized, then sieved using flour sifter with the largest size of 0.210 mm.

Figure 5. Pulverized charcoal
Source: http://surl.li/cjesk

Figure 5 is the representation of pulverized charcoal that is purchased from the nearest store in the specified area of the activity.

2.3 Wood chips

Wood pallets will donate by the beneficiary of this project which is the Rdhan Residential Building Construction. Aspen as wood pallets will be used for the fabrication of particleboards.

Figure 6. Wood chips
Source: http://surl.li/cjeso

3. Mix proportion

Before actual mixing, the container should be clean. It will be labeled based on the mixture.

Before mixing, prepare all the materials needed—first, the pili tree and Antipolo tree sap with pulverized charcoal.

This study will use a thin can with a net content of 16 kilograms for the mixing and heating procedure. The pili and Antipolo tree sap will be placed in a thin can and allowed to melt. While the process of dry mixing, the pulverized charcoal will be added and mixed thoroughly until all materials are thoroughly mixed.

The experimental design for this study, titled "Development of binder for particleboard utilizing Antipolo tree sap and pili tree sap with crushed charcoal," was based on data gathered from a review of related literature. The approach is necessary to fulfill the

study's aims. When placing a wood sample in the experimental program, a mixed percentage is used. MD1 is a 20 percent pili, 60 percent Antipolo replacement ratio for the experiment. MD2 consists of 40 percent pili and 40 percent Antipolo. MD3 consists of 60 percent pili and 20 percent Antipolo. The part of the charcoal will be 20 percent for each set of the mixture since the mixture of two sap variables equals 1000 grams. There are three total mix designs done, each with different content of sap and charcoal.

Table 3.

Mix Proportion in Percentage Form

Mix Design	Pili Tree Sap (%)	Antipolo Tree Sap (%)	Pulverized Charcoal (%)	Wood Chips (%)
MD1	12	4	4	80
MD2	8	8	4	80
MD3	4	12	4	80

Table 4.

Mix Proportion in Specified Weight

Mix Design	Pili Tree Sap (g)	Antipolo Tree Sap (g)	Pulverized Charcoal (g)	Wood Chips (g)
MD1	120	40	40	800
MD2	80	80	40	800
MD3	40	120	40	800

4. Application with particleboard.

The mixed binder shall have an application with particleboard of 4 by 8 feet and 1/2 inch in thickness. During the application process, the mixed binder shall pour in the wood chips with specified mixture content for every specimen.

4.1 Drying of wood chips

Wood particles will be dry at 105^0C for 6 hours in a hot air oven.

4.2 Hot press

The particleboard is pressed using hot compression at 140^0 C cooled to room temperature within 8 minutes.

5. Testing

ASTM D1037 – 99 Standard Test Method for Evaluating Properties of Wood-Base Fiber and Particle Panel Materials. ASTM D570 standard - to determine water absorption rate by immersing the specimen in water for a specific period. According to ASTM D 3502-76 (ASTM 1999), two tests—water immersion and change in relative humidity, namely between 10 and 90 percent—will be used to assess the thickness swelling. Additionally, tests for the Density, Modulus of Rupture and Modulus of elasticity, Face Screw holding and Nail-head pull-through will be performed.

Operation and Testing Procedure

5.1 Moisture content – ASTM D1037-99

Six samples were dried at 103 ±20°C to evaluate the moisture content, and the samples were cut into 5x5 cm squares for each % of adhesive content.

$$MC = \frac{m_1 - m_2}{m_2} x\ 100$$

Where:

MC is moisture content (%)

m_1 is mass of sample before dry (g)

m_2 is mass of sample after dry (g).

5.2 Water absorption – ASTM D570

For each percent of adhesive content, the samples will be cut into 5x5 cm squares. Six samples were subsequently dried at 103 20 °C to assess their moisture. Eight samples will be weighed to record the sample weight before being submerged in water, and the samples will be cut into 5 × 5 cm squares for each % of adhesive concentration (w1). The samples were then submerged in water at a depth of 1 cm from the basin's bottom and 2.5 cm from the water's top. The samples will then be tested under water for two and a half hours. The samples were weighed once again and recorded as a weighted sample after water immersion (w2). The following equation was used to get the WA value. This formula should provide content.

$$WA = \frac{w_2 - w_1}{w_1} x\ 100$$

Where:

WA is water absorption (%)

w_1 is weight of sample before water immersion (g)

w_2 is weight of sample after water immersion (g)

5.3 Thickness and swelling – ASTM D3502-76

For each percent of adhesive concentration, the samples will be cut into 5 × 5 cm squares. The thickness of eight samples was then measured to record the sample's weight before being submerged in water (t1). The samples were then submerged in water at 1 cm from the basin's bottom and 2.5 cm from the water's top. The samples were then analyzed for one hour underwater. The samples were then measured once again to determine their thickness after water immersion (t2). The following equation was used to get the TS value.

$$TS = \frac{t_2 - t_1}{t_1} x\ 100$$

Where:

TS is thickness swelling (%)

t_1 is thickness before water immersion (mm)

t_2 is thickness after water immersion (mm).

5.4 Density

The sample were cut into 5x5 cm for each percentage of adhesive content then six samples were measured (length, width and thickness) and weighed to determine the density using equation.

$$D = \frac{M}{V} \times 10^3$$

Where:

D is density (kg/m3)

M is mass (g)

V is volume (cm3).

5.5 Modulus of rupture and modulus of elasticity

The samples were divided into rectangles of 15 x 5 cm for each percent of adhesive content, and 12 samples were tested using a Universal testing device at a speed of 10 mm/min (Hounsfield H1KS, England). The equation was used to get the MOR and MOE values.

$$fm = \frac{3f_{max}L}{2bt^2}$$

Where:

f_m is MOR (MPa)

F_{max} is maximum force (N)

$$Em = \frac{L^3 F_{max}}{2bt^3 m}$$

Where:

Em is MOE (MPa)

L is span of specimen (mm)

F_{max} is maximum force (N)

b is width (mm)

t is thickness or height (mm)

w is mid displacement (mm).

5.6 Nail-head Pull-through

This test evaluates a composite product's ability to withstand being pulled through a board by the head of a nail or other fastener. It is intended to mimic the circumstances brought on by forces that tend to remove siding or paneling away from a wall. The specimen is 152 mm long and 76 mm broad. Drive a 2.8 mm diameter common wire nail through the test board specimen at a straight angle to the face, flush with the board's surface.

5.7 Face screw holding

This test measures the withdrawal resistance of screws from the face of the board. The specimen for this test is at least 76 mm wide by 102 mm long. Number 10 Type AB 25 mm sheet-metal screws are threaded into the specimen to a depth of 17 mm. Lead holes are predrilled using a bit 3.2 mm in diameter. If the boards are less than 19 mm thick, the specimen is made from two thicknesses of a sample product, which are laminated together with an adhesive. The screw is withdrawn after it has been embedded.

Evaluation Procedure

A survey was undertaken to assess the project's performance. This study has adopted the Technological University of the Philippines evaluation instrument for experimental designs, with the following criteria: Functionality, Aesthetics, Durability, Economy, and Safety. Undertook the following during the evaluation:

1. Researchers conducted a proposal defense composed of 15 people with experience in construction and 15 Civil Engineering students.
2. Researchers explained how the proposed solution works and answered some queries. After the discussion, distribute the evaluation form to the respondents.
3. Let the respondents answer the evaluation form using the Likert Scale in Table 5.
4. Collected data, tabulated, and computed the mean and overall mean.
5. Interpreted the computed numerical data using the range and the descriptive rating in Table 6.

Table 5

Likert Scale

Numerical Scale	Descriptive Rating
5.0	Excellent Highly Acceptable
4.0	Very Good/Very Acceptable
3.0	Good/Acceptable
2.0	Fair/Fairly Acceptable
1.0	Poor/Not Acceptable

Table 6

Descriptive Interpretation of the Mean

Numerical Scale	Descriptive Rating
4.51 - 5.00	Excellent Highly Acceptable
3.51 - 4.50	Very Good/Very Acceptable
2.51 - 3.50	Good/Acceptable
1.51 - 2.50	Fair/Fairly Acceptable
1.00 - 1.50	Poor/Not Acceptable

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