Wood Scraps as Alternative Raw Materials for the Manufacture of Linear Wood Ceiling Plank

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Abstract*: The study investigates the development and performance wood ceiling plank adhere with 60% gorilla glue as a sustainable and economical alternative as ceiling plank materials. It evaluates the mechanical and physical properties of wood ceiling plank, including density, water content, flexural strength, tensile strength and compressive strength based on varying proportions of wood scraps with curing durations of 10 days, following ASTM C140 and ASTM C78/C78M standard. Two mix designs were examined: Mix Design 1 with 10% wood dust, 30% wood shavings, and 60% gorilla glue; Mix Design 2 with 30% wood dust, 10% wood shavings, and 60% gorilla glue. The results show that density increases with low wood dust and wood shavings content, and water content is greater with 30% wood dust with 10% wood chips. Flexural strength is significantly affected by wood scraps, the highest flexural strength, 38.272 MPa, with a mean of 28.57 MPa, was attained after 10 days by Sample 1, which contained 10% wood dust, 30% wood shavings, and 60% gorilla glue. The highest compressive strength, 168.667 MPa, with a mean of 85.4 MPa, was attained after 10 days by Sample 1, which contained 10% wood dust, 30% wood shavings, and 60% gorilla glue. The highest compressive strength, 0.529 MPa, with a mean of 0.52 MPa, was attained after 10 days by Sample 1, which contained 10% wood dust, 30% wood shavings, and 60% gorilla glue. In accordance with the cost analysis, wood ceiling planks are more cost-effective than PVC ceiling planks, with a production cost of ₱4,925.25 as opposed to ₱40,800 for PVC. Thus, a total of ₱35,874.75, is saved. With a composition of 10% wood dust, 30% wood shavings, and 60% gorilla glue, wood ceiling planks provide a combination of strength and cost-effectiveness, making them an economical and eco-friendly building material.

***Keywords*: wood scraps, ceiling plank, gorilla glue.**

1. Introduction

At the beginning of human history, wood was part of it just like stone and clay. It helped create the first tools, houses, and methods of protection for humans [1]. Wood scrap is a more inclusive term that includes any unwanted or discarded materials produced during the processing, manufacturing, or use of wood products, "waste wood" typically refers to wood that is generated as an outcome of a manufacturing or processing process and is not suitable for reuse or recycling [2]. Utilizing wood waste also produces affordable, sustainable, and eco-friendly building materials [3].

A large quantity of wood waste is produced as a result of growing industrial activity worldwide. More than half of the scrap wood that is used for creating concrete forms during construction is discarded. Wood scraps are considered a recyclable and renewable resource, a newly developed concept in circular economy emphasizes a closed-loop process for environmentally conscious material use. In turn, the creation of a new and environmentally friendly approach of turning wood waste into industrial materials with added value is essential [4].

Conduct waste streams analyses and selection of purchase costs rather than the recycling, reusing or remanufacturing processes develop transportation-related emissions (direct pollution), given the amount to be thrown rather recycled, reused or remanufactured. to the landfill: extracting synthetics leave hazardous waste that might leach from landfill; altogether a mindboggling amount of trash in all forms to place somewhere [5]

The ceiling covers the empty space either from above or inside. It's a skin that covers up the elements of what is above, so it lacks construction. The ceiling limits thermal bridges while offering an added aesthetic finish. This makes it comfortable as well and safe for personal use. One of the most important stages in the construction process is the stage of installing a ceiling coating [6].

A. Conceptual Framework

This section presents an overview of the inputs and processes involved in achieving the output for creating linear wood ceiling planks.

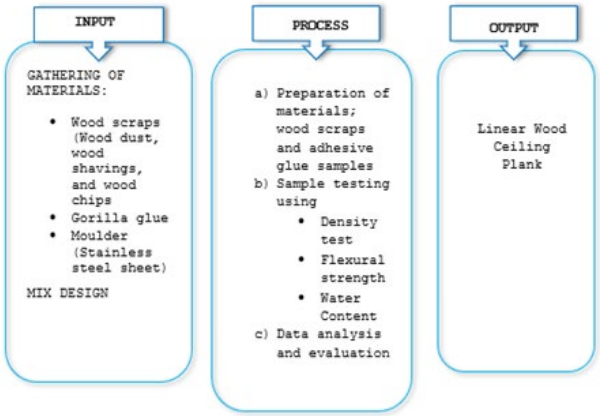

Fig. 1. Conceptual framework of how to utilize wood scraps

Figure.1. explains the materials such as the types of wood scraps that will be used, the wood glue that will be used as the bond material, and the molder made of stainless (which will be in different sizes). Afterward, the wood scraps will be stuck together with the wood glue (Gorilla wood glue), and this will be clamped until it dries for at least 10 counting days. After curing, samples will then undergo to different tests such as density test, flexural strength test, and water content test. Each test will have three different samples. Data will be gathered and tabulated in MS Excel. The expected finished product made up of wood scraps will be linear wood ceiling plank.

B. Statement of the Problem

The objective of this part is to ascertain alternative applications for wood scraps that can be utilized instead of being discarded as garbage. Furthermore, this study specifically addresses the following inquiries:

1. What are the physical and mechanical properties of wood scraps that will be able to produce ceiling plank?
   - *Physical Properties*: Texture, odor, color and hardness
   - *Mechanical Properties*: Compressive strength, moisture content, flexural, density, and tensile strength
2. What is the most efficient ratio of different types of woods scraps and adhesive glue to produce wood ceiling plank?
3. What is the efficient use of wood scraps as linear wood ceiling plank in terms of production cost, material cost, and maintenance cost?

C. Scope and Limitation of the Study

The scope of this study involves the types of wood scraps that will be collected are wood dust, wood chips, and wood shavings. These materials will be molded and will produce at least three samples on each test that will be conducted. The curing time will take 10 days. The data needed for this study will be acquired through mechanical tests such as the Flexural Strength Test and other tests that are available. To ascertain the specimen's flexural strength, the rigidity of the sample after curing was examined using a flexural testing apparatus. This study will be limited to the available data from tests that will be conducted. The expected result from combining these materials is linear wood ceiling planks.

2. Review of Related Literature

This study includes a compilation of literature reviews that are relevant to the research being conducted. This document presents the findings and data acquired from academic databases including Google Scholar, ResearchGate, and ScienceDirect, focusing on physical and mechanical performance and the economic feasibility of bonding of wood scraps and wood glue in manufacture of linear wood ceiling plank.

A. Wood as a Building/Construction Material

Wood is an organic substance that is created by numerous woody plants and has a wide range of characteristics. Typically, the range of values for most wood attributes (the ratio of the greatest value to the lowest value) is more than 2:19 [7].

Wood is generally considered a sustainable construction material and a renewable resource that is in high demand and a vital raw material for building and manufacturing. In addition, changing consumption patterns are producing increasing amounts of waste wood, which can be used as a feedstock for the cascade manufacture of new materials like particleboard [2].

Wood possesses significant precision as a construction material owing to its durability, low weight, environmentally favourable characteristics, and ability to be prefabricated for use in building applications [8]. The advantages of wood over other building components are first, it is strong and durable because this material can be used for building a house to produce furniture. Second, it is renewable and recyclable [9].

B. Properties of Woods

Compared to other materials, wood has good physical and mechanical qualities. Tensile, compressive, and bending stresses can all be handled by wood. Wood also can reduce vibrations [1].

Wood is made up of tissues such as fibers, vessels, tracheae, and other hard fibrous substances found between the pith and the bark [10]. Investigations were done into how the amount of wood fiber, pulverized fly ash (PFA), and incinerated sewage sludge ash (ISSA) affected the mechanical and durability characteristics of wood-MOC board (He et al., 2019).

The tensile strength and flexural strength increased by 144% and 154%, respectively, with the addition of even 3% MAPP as a compatibilizer [11]. That applies to both compression and tension strengths.

C. Ceiling Planks

Because of its many advantages, including its lightweight, processability, good mechanical qualities, sustainability, beautiful appearance, and technological applicability (for wood processing in industrial and handicraft applications), wood is still a vital component of modern construction [12].

The ceiling board is one of the most important non-loads bearing structural elements and a vital line of defense against the overt heat absorption by the tenant [14].

The aim of this study is to examine the characteristics of tiles that use wood waste (sawdust) as a recycled material in order to create ceiling tiles that could be economically feasible, by replacing 50% of the clay with sawdust wherein the ratio are 1:1, 1:2, 1:3, 1:4, and 1:5 were considered in making the ceiling boards [15].

Table 2 shown the wide range of ceiling materials available in the market that can provide you with a sturdy and acoustically sound roof. There is a wide variety of ceiling panel alternatives available for selection. The choice of the appropriate one is contingent upon your personal preference or

the decorative motif of your residence. The choice of ceiling panels is also important upon the specific installation method you intend to employ shown in Table 3.

D. Economical Usage of Wood

Wood material is an abundant and renewable resource that is capable of decomposing naturally and may be easily discarded. In construction it offers not just sustainability advantages but also cost-effectiveness compared to other materials. This is because wood can be used as a rapid and efficient construction method, it is relatively lightweight and easy to transport, and it is highly adaptable [16].

Buildings are occasionally dismantled prior to reaching their lifespan. Their projected lifespan is influenced by fluctuations in land values and user demands. Utilizing wood items in construction can enhance its adaptability to evolving requirements (Sustainability-Fact-Sheet-February-7-2017, n.d.).

The demand for fundamental resources can be diminished by enhancing efficiency in their utilization. It is crucial to prioritize the transition to materials that have lower emissions throughout their entire life cycle. Additionally, we should explore the reuse and recycling of wood products to meet the growing need for wood in the future and potentially decrease the requirement for

Table 1
Advantages and disadvantages of using woods in construction [20]

Advantages	**Disadvantages**
Strong and durable	Costly
Sustainable, renewable, and generally less energy-intensive (Benefits of Wood in Construction,2019)	Combustion
Natural resources	Shrinkage and Swelling Wood as a building material; its benefits and disadvantages (n.d.).
Highly machinable	Easily catches fire.
Strong and durable	Deterioration Wood as a building material; benefits and disadvantages (n.d.).

Table. 2
Material used for ceilings [20]

Materials (Natural materials)	**Uses**
Thatches	Thatched ceilings give building insulation, weather protection, and a distinctive appearance
Plywood	It is used due to variety of reasons such as: Durability, Versatility, Soundproofing, Insulation, False ceilings.
cardboard	A material that may be recycled to create ceiling tiles and utilized as insulation.
particleboard	popular option for ceilings due to its cost-effectiveness and thermal insulation qualities.
Asbestos	The mineral is frequently used for roofing, ceilings, flooring, and insulation. Its fiber strength and fire resistance made it a popular choice in the 1900s.
Plaster of Paris (POP)	It produces intricate designs and smooth finishes, it is frequently used for ceilings.
Polyvinylchloride (PVC)	frequently employed because of its potential aesthetic appeal and versatility in architectural applications.

Table 3
Types of ceiling planks (Veitch, Tom D.)

Types	**Description**
Linear Plank wood ceiling	Generate a distinct allure. The inherent aesthetic qualities of solid wood, such as its unique grain patterns and color variations, will enhance the appearance of your ceiling. Linear plank ceiling can enhance acoustics via sound absorption; it is common for batt insulation to be installed at reveals within the T-Bar grid.
Grille Wood Ceiling	a ceiling made of wood slats that are deeper than they are wide and are attached with dowels. The slats can be made of wood or wood veneer, and the ceiling can be designed in a variety of ways. Design - can make a room look larger Installation - easy installation and access to the plenum. Acoustic benefits - combine the natural beauty of wood

Table 4
Adhesive used in wood

	Types of Adhesives	**Results**	**Citations**
1	Polyurethane wood glue	The material exhibits a wide range of capabilities, including strong bonding, capacity to be used in cold environments, resistance to high temperatures, quick hardening, great durability, and effective protection against chemicals.	[7]
2	Polyvinyl Acetate (PVA) glue	Versatility and resistance to water and heat Composed of a water-based emulsion to enhance the stress and anti-shrink qualities of glass fiber-reinforced polymers	[17],[18]
3	Epoxy	Conventional accelerated tests usually do not consider them capable of making entirely durable connections with wood.	[17]

new wood sourced from forests ("Summary for Policymakers," 2022).

E. Adhesive Glue Used in Wood

Polyvinyl Acetate (PVA) glue is highly esteemed in the woodworking world for its strength, safety, affordability, and water-resistant characteristics. Vinyl acetate has been polymerized to create PVA, a thermoplastic adhesive that is colorless and typically safe. Often known as wood glue, white glue, carpenter's glue, school glue, or PVA glue, this adhesive is composed of a water-based emulsion of a common form of glue. PVA is frequently used to enhance the stress and anti-shrink qualities of glass fiber-reinforced polymers [17].

For many years, the wood industry has employed polyvinyl acetate (PVA), an economical glue. PVA performs terribly in wet and fire environments. PVA adhesive loses its ability to withstand bonding at temperatures above 70°C, and its mechanical performance deteriorates with rising temperatures. While wood products have historically despite a sizable market in the building industry, subpar results PVA-bonded goods may reduce the market share of wood products used in building [18].

Epoxy, sometimes referred to as polyepoxide, is a synthetic polymer that is utilized in the production of adhesives, fillers, and protective coatings for a range of uses. When epoxy resin is liquid, it is viscous, or a thick, runny liquid that cures quickly and sticks to a variety of substrate materials, such as wood, stone, etc. Although being minor wood adhesives, epoxies are important because of their low clamping pressure, gap-filling capabilities, and room temperature cure. As a result, they can be applied to both new construction and the restoration of existing buildings. Epoxies have long been used to join wood in a variety of applications, including boats, airplanes, and wood structure maintenance. For epoxies, lack of bond strength occurs mainly upon water exposure [19].

Table 4 illustrates the different types of adhesive glue used in woods and its bonding results.

3. Research Gaps

The difficulties and restrictions that were discovered after careful analysis of the relevant literature are detailed in this section.

Through conducting several research about using wood scraps as alternative raw materials for ceiling plank, the researchers found only a few studies regarding the said study. The gaps in research studies are shown in table 3, wherein determining the proper and exact proportion of the design mix of adhesive and the raw material are unknown, so trials and experimentations are made upon conducting through different types of testing procedures.

Design flexibility is important to achieve a sustainable product using waste materials. The type of adhesive bond to be used in binding woods scraps and the best ratio to attain the desired strength, durability, and other properties of wood scraps. Having a range of adhesive-bonding technologies is beneficial for assembling components using adhesive bonding. The selection of the application method can limit the design of the final product and impact the choice of manufacturing materials, quality, performance, and assembly cost ("Adhesive Applications and Bonding Processes," 2010). It is essential to know the classification of adhesives before it is used because it has different varieties and ways of usage. Increasing the amount of adhesives in a adherent does not accelerate the drying process or enhance the outcome [21].

4. Methodology Research Process

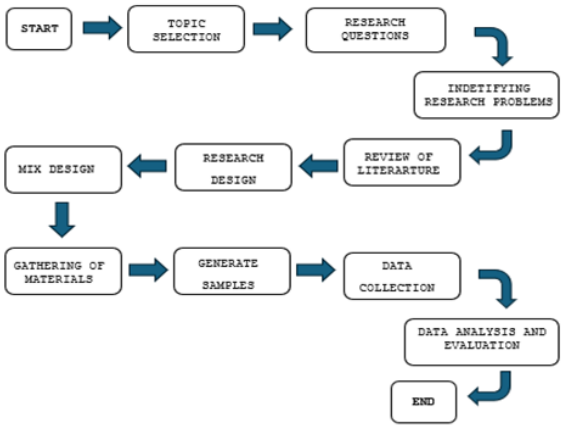

Fig.2. Flowchart of research

A. Flowchart of Research Design

The flowchart shown in figure 2 illustrates the sequential steps that are needed to carry out the desired result. The study involves identifying research problems which will help the researchers to determine the objectives of the study. Gathering and evaluating needed materials and their extent. With these materials, creating three samples in each test, the data will be gathered after physical experimentation. The data will then be tabulated in Microsoft Excel. The process of assessing the study outcomes, including the summary and research findings, is shown in the flowchart.

B. Material Requirements

This section of the study identifies the materials that will be provided for developing the output of the research. This utilizes

Table 5
Challenges in the analysis of the of wood as alternative raw materials for the manufacture of linear wood ceiling planks

No.	Citations	Challenges
1	[23],	Design Flexibility
2		Durability of the adhesive bond
3	[7], [17]	Adhesive glue to be used.
4	[7]	Woods scraps as sustainable building materials
5	[10]	Utilization of large-scale wood in existing additive manufacturing techniques

an overview of the objectives and uses of all the materials used in this research study. Table 6 shows specifically the materials that will be used to build this project.

Table 6
Materials and specifications

No.	Materials	Specifications
1	Wood Scraps	• Wood dust- is generated through woodworking activities such as the wood production of wood products, machines operations, and sanding by hand or machine. • Wood shavings- Wood shaving is the waste obtained when wood is shaped or planed using carpentry tools or machines like planers and milling machines. • Wood chips- Wood remnants obtained from the cutting of logs and the production of solid wood items like lumber and plywood. - usually 4-6 mm thick, 15-20 mm in length and width.
2	Adhesive: Original Gorilla Glue-	• Incredibly strong and versatile; the leading multi-purpose waterproof glue • Gorilla Glue contains urethane prepolymer, diphenylmethane-diisocyanate, isomers, and homologues. • Best for tough repairs on dissimilar surfaces, both indoors and out • 100% waterproof; doesn't break down when exposed to outdoor elements. • Versatile; easily bonds wood, stone, metal, ceramic, foam, glass, concrete and much more! • Incredibly strong: expands 3 times into the materials to form an incredibly strong bond.

C. *Mix Design*

According to (Adeleye et al., 2021) the following mixing ratios are shown. The number of materials (Mix design 1: wood dust: wood shaving: gorilla glue) & (Mix design 2-wood dust: wood chips: gorilla glue) used to produce each wood plank sample with the dimensions 130mm width and 610mm length were calculated.

Table 7
Mixing ratio

SAMPLE NUMBER	MIXING RATIO	WOOD SCRAPS/GLUE	WEIGHT (grams)
1	10%:30%:60%	Wood dust= 416g x 10% Wood shavings= 1150g x 30% Gorilla glue= 2141g x 60%	41.6g 345g 1284.6g
2	30%:10%:60%	Wood dust= 416g x 30% Wood chips= 753g x 10% Gorilla glue= 2141g x 60%	124.8g 75.3g 1284.6g

Table 8
Specifications for testing procedures

Test Method	Length (mm)	Width (mm)	Thickness (mm)	No. of samples per mix design
Density	50	50	25	2
Flexural Strength test	130	15	25	2
Water Content (oven drying test)	75	50	25	2
Compressive Strength test	50	50	25	2
Tensile Strength Test	125	13	25	2

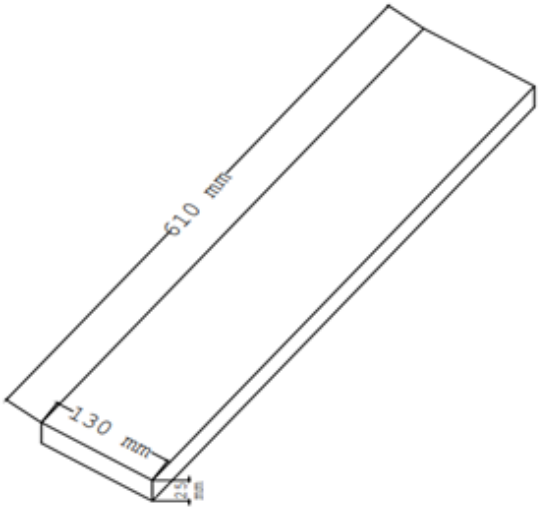

Fig. 3. Linear wood ceiling plank dimension

D. *Laboratory/Experiment/Field Experiment*

To determine the durability and strength of the specimen these methods and tests were utilized.

E. *Density Test*

To know if the specimen is strong, and has a good quality, a density test is conducted. Specifically, wood density is the ratio of the oven-dried mass of the specimen divided by the volume of the specimen.

F. *Flexural Strength Test*

In this study, the specimen will undergo a 4-point bend test using ASTM C78/C78M to measure the deflection at the center of the specimen.

G. *Moisture Content*

In this study, the method we're going to use for testing water content is oven-dry testing. The formula to determine the water content of the specimen is shown below.

H. *Compressive Strength Test*

A mechanical test that determines the highest compressive load a material can withstand before breaking. Next, a gradually applied stress will compress the specimen between the platens of a compression-testing machine.

I. *Tensile Strength Test*

Measures the specimen's resistance to tension or stretching.

J. *Description of Research Instrument Used*

In this study, the researchers will use different testing equipment's to determine the compressive strength, moisture content, flexural strength, and density of woods scraps mixture using adhesive glue as a ceiling plank. The researcher will employ flow charts to assess the data generated through various methods, such as experimentation, observation, and testing. The data to be collected will be tabulated using MS Excel for the

comparison of results. And we will also be using AutoCAD for the 3D view of the product output. The researcher will develop an environmentally friendly yet durable linear wood ceiling plank from wood scraps.

5. Result and Discussion

A. Density Test of Wood Ceiling Plank

Figure 4 presents the results gathered from the density test. Following the established standards of ASTM C140, the density test procedure was properly. The selected specimen was oven-dried after 10 days of curing.

As shown in the figure, the saturated weight, immersed weight, and oven-dry weight were all measured during the test. To be able to determine the density using the formula given in the density measurement section, volume measurements were also taken.

The density of the wood ceiling plank with a mixture of 10% wood dust, 30% wood shavings and 60% of gorilla glue. Based on the graph indicated, the Mix 2 - Sample 2 (10 days) has a highest density of 543. 71 kg/m³ and the lowest density is Mix 1 - Sample 1 (10 days) around 394.456 kg/m³.

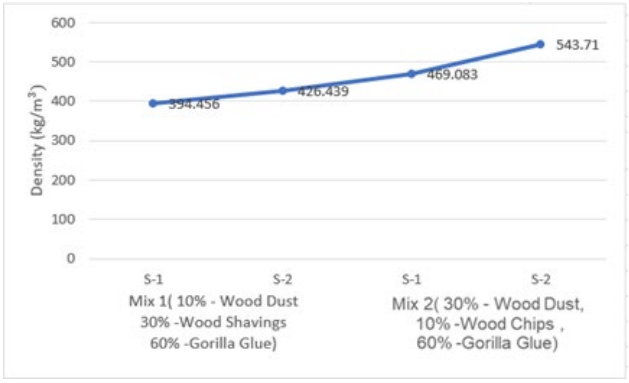

Fig. 4. Density measurement result

B. Water Absorption Test of Wood Ceiling Plank

Figure 5 presents the results gathered from the water content test. Following the established standards of ASTM C140, the water content test procedure was properly carried out, and the selected specimen was oven-dried after 10 days of curing for 24 hrs.

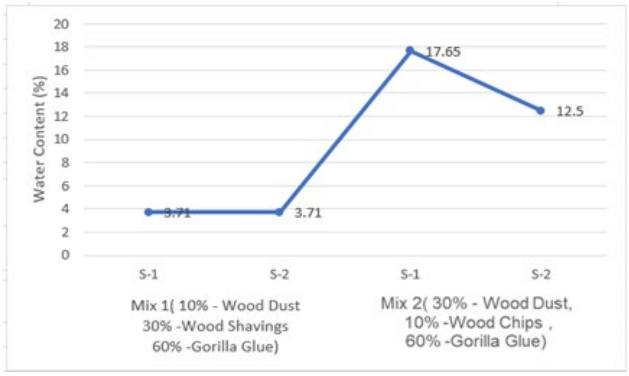

Fig. 5. Water absorption test result

From the results obtained in Fig. 5 for Water Content (WC) properties, water resistance was lowest in planks made from wood ceiling plank with a mixture of 10% of wood dust, 30% wood shavings and 60% of gorilla wood glue while water resistance was highest when wood ceiling plank with a mixture of 30% of wood dust, 10% wood chips and 60% of gorilla wood glue. The decrease in the WC may be explained by the fact that numerous void areas are filled as the wood chips and wood dust increases, which makes it more likely that the bonded wood scraps will be mixed thoroughly and uniformly. This phenomenon can also be explained by the wood glue and wood scraps' compatibility, which resulted in a good connection, less void areas, and a lower rate of water content.

C. Flexural Test of Wood Ceiling Plank

Considering the properties of wood scraps adhere to gorilla glue is an environmentally sustainable approach that helps reduce pollution from traditional wood ceiling plank composition, aligning with a global movement toward greener construction materials. This highlights the value of research, particularly in evaluating the effectiveness of gorilla glue as a reinforcement material. The mixture of wood scraps and gorilla glue ratio has been studied to determine its effectiveness in increasing axial load capacity. As presented in the table, the results show a notable increase in flexural strength. Following the guidelines of ASTM C78/C78M, the flexural strength test was carefully conducted using the three-point bending test on the compression testing machine to ensure consistent and accurate results.

Table 9
Flexural strength test result

MIXED DESIGN	Sample Composition	Sample No.	10 DAYS Strength (Mpa)
1	10% - Wood Dust 30% -Wood Shavings 60% -Gorilla Glue	S-1	38.272
		S-2	18.859
2	30% - Wood Dust 10% -Wood Chips 60% -Gorilla Glue	S-1	17.472
		S-2	12. 341

In result, the findings show that the percentage of wood scraps, gorilla glue, and curing time have a substantial impact on the flexural strength of the wood ceiling plank. The highest flexural strength, 38.272 MPa, with a mean of 28.57 MPa, was attained after 10 days by Sample 1, which contained 10% wood dust, 30% wood shavings, and 60% gorilla glue. Sample 2 demonstrated moderate strength improvements, reaching 14.91 MPa, with 30% wood dust, 10% wood chips, and 60% gorilla glue. According to the results, wood dust, wood shavings and drying time have a major effect on the flexural strength of wood ceiling planks. Strength declines as wood dust content rises and

wood chips content; the largest proportion of wood dust (30%) and wood chips (10%) shows a consistent decline in strength over time. After 10 days, Sample 1, which contained 10% wood dust, 30% wood shavings, and 60% gorilla glue, had the maximum flexural strength, suggesting that the ideal wood dust-to-wood shavings-to-gorilla glue ratio for strength is balanced.

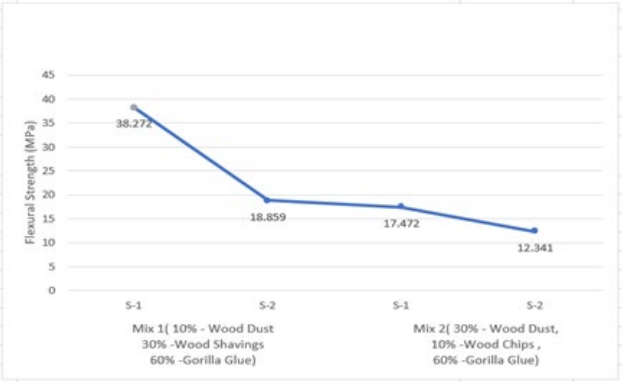

Fig. 6. Average flexural strength test result

D. Compressive Strength Test of Wood Ceiling Plank

Considering the properties of wood scraps adhere to gorilla glue is an environmentally sustainable approach that helps reduce pollution from traditional wood ceiling plank composition, aligning with a global movement toward greener construction materials. This highlights the value of research, particularly in evaluating the effectiveness of gorilla glue as a reinforcement material. The mixture of wood scraps and gorilla glue ratio has been studied to determine its effectiveness in increasing axial load capacity. As presented in the table, the results show a notable increase in flexural strength. Following the guidelines of ASTM C78/C78M, the compressive strength test was carefully conducted using the three-point bending test on the compression testing machine to ensure consistent and accurate results.

Table 10
Compressive strength test result

MIXED DESIGN	Sample Composition	Sample No.	10 DAYS Strength (Mpa)
1	10% - Wood Dust 30% -Wood Shavings 60% -Gorilla Glue	S-1	168.667
		S-2	2.132
2	30% - Wood Dust 10% -Wood Chips 60% -Gorilla Glue	S-1	2.568
		S-2	2.28

In result, the findings show that the percentage of wood scraps, gorilla glue, and curing time have a substantial impact on the compressive strength of the wood ceiling plank. The highest compressive strength, 168.667 MPa, with a mean of 85.4 MPa, was attained after 10 days by Sample 1, which contained 10% wood dust, 30% wood shavings, and 60% gorilla glue. Sample 2 demonstrated moderate strength improvements, reaching 2.42 MPa, with 30% wood dust, 10% wood chips, and 60% gorilla glue. According to the results, wood dust, wood shavings and drying time have a major effect on the compressive strength of wood ceiling planks. Strength declines as wood dust content rises and wood chips content; the largest proportion of wood dust (30%) and wood chips (10%) shows a consistent decline in strength over time. After 10 days, Sample 1, which contained 10% wood dust, 30% wood shavings, and 60% gorilla glue, had the maximum compressive strength, suggesting that the ideal wood dust-to-wood shavings-to-gorilla glue ratio for strength is balanced. Mix 1 (Sample 1) had the highest compressive strength because it is horizontally tested than other samples.

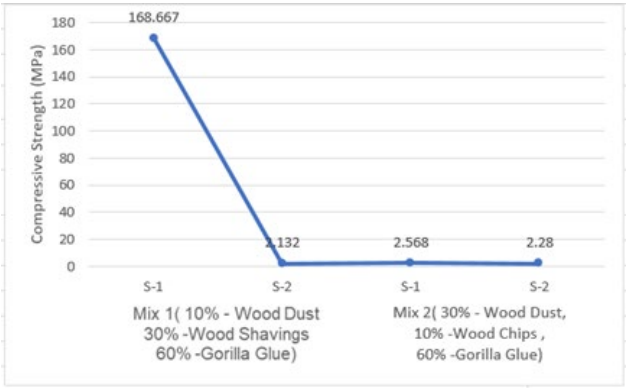

Fig. 7. Compressive Strength Test

E. Tensile Strength Test of Wood Ceiling Plank

Considering the properties of wood scraps adhere to gorilla glue is an environmentally sustainable approach that helps reduce pollution from traditional wood ceiling plank composition, aligning with a global movement toward greener construction materials. This highlights the value of research, particularly in evaluating the effectiveness of gorilla glue as a reinforcement material. The mixture of wood scraps and gorilla glue ratio has been studied to determine its effectiveness in increasing axial load capacity. As presented in the table, the results show a notable increase in tensile strength. Following the guidelines of ASTM C78/C78M, the tensile strength test was carefully conducted using the three-point bending test on the compression testing machine to ensure consistent and accurate results.

Table 11
Tensile strength test result

MIXED DESIGN	Sample Composition	Sample No.	10 DAYS Strength (Mpa)
1	10% - Wood Dust 30% -Wood Shavings 60% -Gorilla Glue	S-1	0.511
		S-2	0.529
2	30% - Wood Dust 10% -Wood Chips 60% -Gorilla Glue	S-1	0.511
		S-2	0.517

In result, the findings show that the percentage of wood

scraps, gorilla glue, and curing time have a substantial impact on the tensile strength of the wood ceiling plank. The highest compressive strength, 0.529 MPa, with a mean of 0.52 MPa, was attained after 10 days by Sample 1, which contained 10% wood dust, 30% wood shavings, and 60% gorilla glue. Sample 2 demonstrated moderate strength improvements, reaching 0.514 MPa, with 30% wood dust, 10% wood chips, and 60% gorilla glue. According to the results, wood dust, wood shavings and drying time have a major effect on the tensile strength of wood ceiling planks. Strength declines as wood dust content rises and wood chips content; the largest proportion of wood dust (30%) and wood chips (10%) shows a consistent decline in strength over time. After 10 days, Sample 1, which contained 10% wood dust, 30% wood shavings, and 60% gorilla glue, had the maximum tensile strength, suggesting that the ideal wood dust-to-wood shavings-to-gorilla glue ratio for strength is balanced.

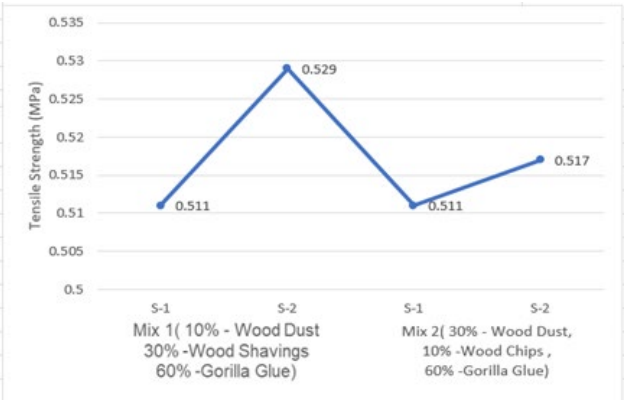

Fig. 8. Average tensile strength test result

F. Cost Analysis

This section presents a comparative cost analysis of using Wood Ceiling Plank versus PVC Ceiling Plank for a 100-square-meter ceiling construction. Based on the standard board dimensions and total area required, it was determined that 136 wood ceiling planks would be needed for the project. To determine the cost-effectiveness of Wood Ceiling Plank, the price per board was calculated based on a sample cost for producing 4 planks, which totaled 145 pesos.

Table 12
Units cost of 4 pcs wood ceiling plank (Specimen 1)

A. MATERIALS: CONST	UNIT	QUANTITY	UNIT COSTS	TOTAL COST
Wood Scraps	sack	1	0.00	0.00
Gorilla Glue	oz	0.20	497.00	100.00
Subtotal (A)				100.00
B. LABOR COST	**No.of Person**	**Total Hours**	**HOURLY RATE**	**TOTAL COST**
Welder	1	0.5	90	45.00
Subtotal (B)				45.00
Total Direct Cost				145.00

A rough estimate of 36.25 pesos per wood ceiling board was obtained by dividing this sum by the number of planks. This amount was used to determine that the total cost of manufacturing 136 wood ceiling planks was 4,925.25 pesos. In contrast, it was discovered that a single PVC ceiling plank cost 300 pesos, meaning that 40,800 pesos would be needed for the same quantity of boards. With a total savings of 35, 874.75 pesos when compared to PVC ceiling plank, this comparison demonstrates a definite pricing benefit of adopting wood ceiling plank. Because of these reductions, wood ceiling planks can be a very affordable option, particularly for building projects with limited funds or resources.

The feasibility of using gorilla glue to adhere wood ceiling planks as an affordable ceiling material was also assessed in the study. The results not only showed material performance compatibility but also pointed to workable ways to make wood ceiling planks out of mixes of wood scraps. Without compromising structural integrity, this method significantly reduces construction costs while advancing environmental sustainability.

6. Conclusion

This study investigates the use of wood ceiling plank bond with gorilla glue as an environmentally friendly and sustainable house ceiling material. The research demonstrates that the mix of wood scraps affects the mechanical properties of the materials, particularly the flexural strength, compressive strength, tensile strength, density and water absorption. Therefore, the research concluded that:

- The results indicate that the density of the wood ceiling plank depends on wood scraps percentage. With the combination of wood dust and wood chips, the density increases.
- Increasing the percentage of wood dust with wood chips lowers the plank's flexural strength, compressive strength, and tensile strength.
- Sample 1 in mixture design 1 was tested horizontally that's why it has the highest Compressive Strength among the four samples.
- The water resistance was lowest in planks made from wood ceiling plank with a mixture of 10% of wood dust, 30% wood shavings and 60% of gorilla wood glue while water resistance was highest when wood ceiling plank with a mixture of 30% of wood dust, 10% wood chips and 60% of gorilla wood glue.
- The cost analysis highlighted that wood ceiling plank is significantly more economical than PVC ceiling plank, making them a viable alternative in communities with limited financial resources.

A. Recommendations:

The primary objective of this project is to use wood scraps to make environmentally friendly and economical building materials. Identifying the problem of inadequate use of wood

waste and investigating its potential to generate sustainable wood ceiling planks are the goals of this study.

- Long-term durability evaluations of wood ceiling planks could be the subject of future studies.
- Further research on bond glue's accessibility, affordability, and drying ease.
- Further research focused on how long the curing time if it is long or short time.
- An environmental effect analysis of these wood ceiling planks is advised for further research.
- More research into more effective ways to use wood scraps

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