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COCONUT FIBER AND PULVERIZED RICE HUSK AS ALTERNATIVE INGREDIENTS IN CONSTRUCTING CEMENT BOARD

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Abstract:

Improper disposal of agricultural waste is causing problems in the world today. Since it was seen that using rice husk and coconut fiber can help humans and their environment, this study investigated if coconut fiber and risk husks are potential alternative ingredients in making cement boards. With this, a quantitative experimental design was used to answer the questions this study sought. After the experiment, it was found that rice husk-coconut fiber is not feasible enough in terms of its flexural strength; however, using the rice husk-coconut fiber cement board for interior purposes is recommended. With the limitations of the study, it is also recommended for future researchers to survey rice husk-coconut fiber cement board to use variations with higher water, rice husk, coconut fiber, and cement ratio that can improve the strength and durability of the rice husk-coconut fiber cement board.

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Rice Husk, Coconut Fibers, Cement Board, Experimental Design

Introduction

Cement has been one of the most valuable building materials since the dawn of human civilization, and it has been used in different types of buildings and infrastructures throughout history. Furthermore, cement paved the way for humans to create new structures that would benefit civilization for the rest of the years. Many ancient structures in Greece and Rome are still standing because of the materials that the people used. Accordingly, the mixture of quicklime and volcanic ash would harden with water and not break down in water. This mixture was combined with stone and used liberally on everything from roads, castle walls, and watercourses to houses and temples (Shimoda, 2016). Clay and the hydraulic properties of hydraulic lime, produced from a natural mixture of limestone and clay and serves as a binder for water-resistant mortar, were also used. The continuous use of cement in the past and present helped a lot in improving humanity's progress, and halting the process of creating cement would hinder progress in society.

Moreover, the use of cement is prominent in every part of the world due to its reliability. Cement is one of the materials that is used to create concrete. These concretes are then used to construct infrastructure. There are also products that cement can produce, one example of which is the cement board. According to Ranachowski (2018), cement boards are sheets of cement and fibers containing cellulose. Boards are typically four (4) feet by eight (8) feet in dimension, varying between ¼ and ½ inch in thickness. The primary purpose of cement boards is to serve as backing for tile and are superior to paper-covered gypsum at this task because of their water resistance – as tile is typically used in areas prone to water exposure, it is essential to have a backing that will not develop mold and mildew or disintegrate after prolonged exposure to moisture.

Rice husk, according to Singh (2018), constitutes about 20% of the weight of rice, and its composition is as follows: cellulose (50%), lignin (25%–30%), silica (15%–20%), and moisture (10%–15%). The bulk density of rice husk is low and lies in the 90–150 kg/m3 range. Rice Husk components are an advantage in the Properties of Concrete. On the other hand, Amin and Abdelsalam (2019) said that rice husks contain high amounts of silica (SiO_2). Hence, it can be used as a supplementary cementitious material in combination with cement to make concrete products. This material provides advantages that provide good compressive strength to the concrete, help in reducing environmental pollution, and make an excellent supplementary cementitious material. The density of concrete containing rice husk is similar to the standard weight concrete; hence, it can also be used for general-purpose applications. The impervious microstructure of rice husk concrete provides better resistance to sulfate attack, chloride ingress, carbonation, etc., and rice hull concrete has suitable shrinkage properties and increases

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the durability of concrete (Amin & Abdelsalam, 2019). Besides, a note from Bee Chems (2022) said that adding rice husk silica to the concrete mix, even in low replacement, can dramatically enhance the strength of concrete by 10-20%. Rice husk silica helps develop excellent water-resistant properties and is used in waterproofing compounds that can reduce water penetration by as much as 60%.

Additionally, rice husks are often used to add or replace an existing commodity in construction materials. According to Chabi et al. (2020), rice husks are compatible with cement. In addition, it was said that rice husks can be used as building materials, especially in countries with tropical or arid climates. Despite the abundant nature of this waste product, it is not being used to its maximum capacity. Though rice husks have been used in a variety of things across the world (Liu et al., 2016) examined the potential uses of rice husks in the production of bedding materials, animal feeds, soil conditioners, fertilizer, biofuel, organic and inorganic chemicals, abrasive components, carbon, paper board manufacturing, and others. For instance, the study of Ahiduzzaman (2007) discussed using rice husks as a renewable energy source in a developed country like the United States. In Bangladesh, rice husks are used as briquettes for cooking, which becomes a substitute for coal. These briquettes are smokeless and provide a higher temperature than coal or wood. Rice husks also melt bitumen in road construction (Ahiduzzaman, 2007). In the country, only a tiny amount of this product is being utilized purposefully. Rice husks are burned to become fertilizer to the soil and as feed for the domestic animals.

Along with rice husk, coconut fibers are also seen to be an alternative ingredient in constructing cement boards. In context, coconut is an abundant biomass resource in tropical countries. Espina et al. (2022) said the Philippines planted 347 million coconut trees, producing 14.7 million tons of coconuts in 2020. The coconut shells (endocarp) are considered a waste material, comprising 15.18% of each fruit and accounting for 2.2 million tons. The Philippines has the most significant number of coconut trees worldwide as it produces most of the world market for coconut oil and copra meal. The major coconut wastes include coconut shells, coconut husks, and coconut coir dust. Coconut shells are the most widely utilized, but the reported utilization rate could be higher. Approximately 500 million coconut trees in the Philippines produce tremendous amounts of biomass, such as husk (4.1 million tons), shell (1.8 million tons), and fronds (4.5 million tons annually) (Zafar, 2021).

Furthermore, the coir, also known as coconut fiber, is a natural fiber extracted from the husk of coconuts. It consists of short fibers or strands. It has a variety of uses in manufacturing, construction, and agriculture. It can make brushes, doormats, flooring material, insulation, ropes, and string for fishing nets (Sathish et al., 2017). In addition, coir fibers are often used as a growing medium in hydroponic systems or to make biodegradable plant pots; coir is used extensively in the manufacturing and construction industries. It also produces insulation materials such as roofing felt and wallpapers. Additionally, coir can be a helpful component in manufacturing mattresses, carpets, and even automobile components. It can also make animal bedding and produce biodegradable packaging materials. It is also sometimes used in erosion control systems, particularly on steep slopes and riverbanks (Sathish et al., 2017).

Moreover, in the study of Ranjitham et al. (2019), coconut fibers have the best toughness among all natural fibers. Because of their toughness and sturdiness, these coir fibers tend to be used as reinforcement in low-cost concrete structures, particularly in earthquake regions.

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Besides, this material provides coconut fiber's advantages: toughness, insect proof, resistance to fungi and decay, and good insulation against temperature and sound. Because of their toughness and sturdiness, these coir fibers tend to be used as reinforcement in low-cost concrete structures, particularly in earthquake regions. They remain unaffected by external factors like humidity.

Literature Review

Rice Husk

Rice husks are the outer covering of rice grains, which become waste after rice milling. Asian countries are known as the worldwide source of rice, where 88% of the Global Rice harvested is found. It is equivalent to 137 million hectares out of 154 million hectares (Faostat, 2012). Despite the abundant nature of this waste product, it is not being used to its maximum capacity. In the Philippines, only a tiny amount of this product is being utilized purposefully. Rice husks are burned to become fertilizer to the soil and as feed for the domestic animals.

Rice husks have been used in a variety of things across the world (Liu et al., 2016) examined the potential uses of rice husks in the production of bedding materials, animal feeds, soil conditioners, fertilizer, biofuel, organic and inorganic chemicals, abrasive components, carbon, paper board manufacturing, and others. Ahiduzzaman (2007) also discussed using rice husks as a renewable energy source in a developed country like the United States. In Bangladesh, rice husks are used as briquettes for cooking, which becomes a substitute for coal. These briquettes are smokeless and provide a higher temperature than coal or wood. Rice husks also melt bitumen in road construction (Ahiduzzaman, 2007).

Rice husk constitutes about 20% of the weight of rice, and its composition is as follows: cellulose (50%), lignin (25%–30%), silica (15%–20%), and moisture (10%–15%). The bulk density of rice husk is low and lies in the 90–150 kg/m3 (Singh, 2018). Rice Husk components are an advantage in the Properties of Concrete. Amin and Abdelsalam (2019) state that rice husk contains high silica (SiO_2). Hence, it can be used as a supplementary cementitious material in combination with cement to make concrete products. This material provides advantages that provide good compressive strength to the concrete, help in reducing environmental pollution, and make an excellent supplementary cementitious material. The density of concrete containing rice husk is similar to the standard weight concrete; hence, it can also be used for general-purpose applications. The impervious microstructure of rice husk concrete provides better resistance to sulfate attack, chloride ingress, carbonation, etc., and rice hull concrete has suitable shrinkage properties and increases the durability of concrete (Amin & Abdelsalam, 2019). Adding rice husk silica to the concrete mix, even in low replacement, can dramatically enhance the strength of concrete by 10-20%. Rice Husk silica helps develop excellent water-resistant properties, and it is used in waterproofing compounds that can reduce water penetration by as much as 60% (Bee Chems, 2022)

Coir

Coir, also known as coconut fiber, is a natural fiber extracted from the husk of coconuts. It consists of short fibers or strands. It has a variety of uses in manufacturing, construction, and agriculture. It can make brushes, doormats, flooring material, insulation, ropes, and string for fishing nets (Sathish et al., 2017). Coconut is an abundant biomass resource in tropical countries. According to Espina et al. (2022), In 2020, the Philippines planted 347 million

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coconut trees that produced 14.7 million tons of coconuts. The coconut shells (endocarp) are considered a waste material, comprising 15.18% of each fruit and accounting for 2.2 million tons. The Philippines has the most significant number of coconut trees worldwide as it produces most of the world market for coconut oil and copra meal. The major coconut wastes include coconut shells, coconut husks, and coconut coir dust. Coconut shells are the most widely utilized, but the reported utilization rate is meager. Approximately 500 million coconut trees in the Philippines produce tremendous amounts of biomass, such as husk (4.1 million tonnes), shell (1.8 million tonnes), and fronds (4.5 million tonnes annually) (Zafar, 2021).

Coir fibers are also often used as a growing medium in hydroponic systems or to make biodegradable plant pots; coir is used extensively in the manufacturing and construction industries. It also produces insulation materials such as roofing felt and wallpapers. Additionally, coir can be a helpful component in manufacturing mattresses, carpets, and even automobile components. It can also make animal bedding and produce biodegradable packaging materials. It is also sometimes used in erosion control systems, particularly on steep slopes and riverbanks (Sathish et al., 2017).

The coconut husk comprises 30% fiber and 70% pith, with high lignin and phenolic content. Due to the high lignin content, coconut fiber is very elastic, durable, and resistant to rotting. According to Yalley (n.d), adding coconut fibers significantly improved many of the engineering properties of the concrete, notably torsion, toughness, and tensile strength. The ability to resist cracking and spalling was also enhanced. This material provides the advantages that coconut fiber provides: toughness, insect proof, resistance to fungi and decay, and provides good insulation against temperature and sound. Because of their toughness and sturdiness, these coir fibers tend to be used as reinforcement in low-cost concrete structures, particularly in earthquake regions. They remain unaffected by external factors like humidity. They act as reinforcement substances by giving strength to the composite (Ranjitham et al., 2019).

Cement

Cement is the binding material used in construction projects. To secure the infrastructure, it adheres to building units such as tiles, bricks, rocks, and stones. Cement, in general, is an adhesive substance of all kinds, but in a narrower sense, it is the binding material used in building and civil engineering construction (Sahana, 2022). Cement is used because of its versatility, availability, high binding strength, fire resistance, and cost-effectiveness.

A cement board combines cement and reinforcing fibers formed into sheets of varying thicknesses typically used as a tile backing board. Cement board is the most common material used under tile installed on floors, walls, countertops, and backsplashes. Its purpose is to support the tile, which needs a level surface to avoid cracking. Cement Board is used because of its long life span, versatility, minimal maintenance required, fire heat, and weather resistance. According to Ranachowski (2018), combining cement and fiber helps cement boards have long-term durability. The average lifespan of fiber cement siding is roughly 40 years. A cement board is a fire-resistant board that also insulates from heat. The material has almost a 90% fire-repellent rating, which could significantly restrict the spreading of flames when compared to wood and other more flammable materials; due to its unique curing process, this siding absorbs less moisture than other materials, which means the chance of prone to cracking or breaking is low.

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The fiber sample was combined with cement and water in the following proportions: cement: fiber sample: water, 1:2:1, 1:1:1, and 2:1:2 until homogeneous. The mixture was molded in 350 mm x 350 mm x 10 mm molds (Asasutjarit et al., 2007).

Methodology

Research Design

The researchers employed a quantitative method, specifically an experimental research design, in this study. According to Baker (2017:156), quantitative research designs are often used to look at causal relationships, but they can also look at associations or relationships between variables. Since this study is experimental, intervention was done to observe outcomes or effects (Shadish et al., 2002). Thus, investigating if rice and coconut husk were effective ingredients in alternative cement boards. In addition, these two variables were studied to see the effect of their comparison to another variable.

Research Tools and Materials

During the research process, the researchers used different tools to gather the data needed for their experimental research. The procedure for making cement boards is based on Clayton Kim's "How to Make Cement Board." The testing procedure is based on the University of New South Wales (UNSW Sydney, 2021) bending test and Indian Standard 14862 (Bureau of Indian Standards, 2000). A saw, plywood, pencil, and ruler were used to create the molder. The saw was used for cutting the plywood, and the pencil was used for marking and labeling. At the same time, the ruler was also used to measure the plywood dimensions used to create the molders. The researcher used a blender to pulverize the rice husk to prepare the ingredients.

Data Gathering Procedure

The first procedure in making the alternative cement board was to prepare the ingredients to pulverize the rice husk. Afterward, they measured the right ingredients corresponding to the abovementioned ratios. The rice husk, coconut fiber, and cement were measured using a digital weighing scale, while a measuring cup measured the water. The first ratio is composed of 360g cement, 360g coconut fiber, 360g rice husk, and 450g water. The second ratio is composed of 540g cement, 270g coconut fiber, 270g rice husk, and 540g water. Lastly, the third ratio is composed of 720g cement, 180g coconut fiber, 180g rice husk, and 720g water. After measuring the exact amount needed for each variation, the researchers prepared the coconut fibers and the rice husk for mixing. The ingredients were manually mixed in a mixing bowl using a wooden stick. The 360g of cement was placed first in the mixing bowl, mixing the ingredients. The available measuring cup can only measure a maximum of 250 ml, so the researcher used a 10 ml measuring cup. For the first ratio, the water ratio was measured and then placed in the mixing bowl one time with the 250ml and another eleven times with the 10 ml measuring cup, making a total of 360g of water ratio. Likewise, with the other ratio, the water was measured and placed in the mixing bowl various times with their different ratios. All the mixtures were placed into a molder (350mm x 350mm x 10mm). The molder containing the mixture was then set aside for at least 24 hours under pressure for the mixture to be compacted and was set to be sundried for two days. Sun drying was done to dry the mixture's outer part. After the sun drying, the cement board was set to a dry place to let it cool. The cooling process was done to assist the material in its hardening. After the cooling process, the ratio was added to the testing process.

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In testing the flexural or bending strength, the researcher applied a three-point bending test set-up, where two chairs were used to support the ends of the cement board. The distance from the center to one end is the same as the other. The end-to-end measurement should not be less than 18e, where *e* is the thickness of the product. Meanwhile, a string was used as a weight holder, starting at 7kgf (7000-gram force), 10% of the expected maximum load. The string will then be placed at the center of the cement board and loaded continuously at a rate of +1 kgf for every 30 seconds. If breakage did not occur within 10 to 30 seconds, the researcher added another load. The string was also used to ensure the loads hung on the cement board without touching the ground. By the time the cement board broke, the addition of load was stopped, and the total weight of the load was recorded. The procedures were done in two trials per ratio, and the data gathered were then recorded.

The researchers observed safety measures, so they used hand gloves to protect their skins from being eaten by the cement while making the cement board. Also, the researchers used a face mask in order to protect themselves from inhaling cement powder and other debris, which is unhealthy.

Data Analysis

By the time the researchers finished constructing the product, which is the rice husk and coconut fiber cement board, they had recorded and tabulated all the data available from the product. These data will be subjected to the following tests to answer the questions that this study seeks. The following formula was used for the bending strength test, which is based on Rahman (2021b), while the materials and procedure are based on the Bureau of Indian Standards (2000) and UNSW Sydney (2021).

Flexural or Bending Strength Test

The formula below will be used to calculate the flexural or bending strength. The modulus of rupture denoted by R is calculated through the product of maximum load and length multiplied by three (3) divided by the product of width multiplied by two and the square of the depth or the measured thickness. The resulting answer was expressed in units of kilogram-force per centimeter squared.

$$R = \frac{3PL}{2bd^2}$$

Where:

R = Modulus of Rupture
P = maximum load, kg
L = Length, cm
b = Width, cm
d = depth or thickness, cm

Tukey-Kramer Multiple Comparison Test

In order to answer the statement of the problem, the researchers utilized Tukey-Kramer Multiple Comparison Test as the statistical tool since this study has four independent variables, which are the original cement board; Variation A (360g cement: 360g coconut fiber: 360g rice husk: 450g water), Variation B (540g cement: 270g coconut fiber: 270g rice husk: 540g water), and Variation C (720g cement: 180g coconut fiber: 180g rice husk: 720g water) alternative cement boards and one dependent variable which is bending or compressive

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strength of each variation of cement boards. Each variation of alternative cement board was tested individually with the original cement board to acquire the means of each. The test is conducted two (2) times to measure the dependent variables.

Tukey's multiple comparison test is one of several tests that can determine which means amongst a set of means differ from the rest. The test compares the difference between each pair of means with appropriate adjustment for the multiple testing (Olleveant, 2002). Multiple comparison tests (MCTs) are performed several times on the mean of experimental conditions. When the null hypothesis is rejected in a validation, MCTs are performed when certain experimental conditions have a statistically significant mean difference or a specific aspect between the group means (Lee & Lee, 2018).

$$\text{HSD} = q\sqrt{\frac{MSw}{n}}$$

Where:

HSD = Honest Significant Difference
q = standardized range statistics
MSw = the mean square within groups from the ANOVA
n = the number of variables in each group (variables in groups be in equal size)

Furthermore, the interpretation of the data was based on the American Society for Testing and Materials and the Indian Standard for Fiber Cement. It presents a construction board's minimum to maximum load range in Kilogram-force per centimeter squared and their category.

Table 1. The Standard Modulus Of Rupture Of Construction Boards In Kilogram-Force Per Centimeter Squared

Kgf/cm^2	Interpretation
15.3 – 24.47 (1.5-2.4 MPa)	***Gypsum board*** – gypsum boards are used for interior purposes such as walls, ceiling, and finishing surfaces for walls.
40.79 – 224.34 (4-22 MPa)	***Type B sheet of cement board*** – These are intended for internal and external applications without being subjected to the direct action of sun, rain, and snow.
71.38 – 183.55 (7-18 MPa)	***Type A sheet of cement board*** – These are intended for external application, where they may be subjected to direct action of sun, rain, and snow.

Results and Discussion

Flexural or Bending Strength

The flexural strength of a material is defined as the highest bending stress that may be given to it before it yields. Bending strength, modulus of rupture, and transverse rupture strength are all terms for flexural strength (Trenchlesspedia, 2018). It also measures the force an object can take and withstand without permanently breaking or deforming (Birchall et al., 1981). The

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flexural strength is represented by the rupture modulus and expressed in different units like kilogram-force per square centimeters and kilopascal.

Table 2. The Flexural Or Bending Strength Of Rice Husks And Coconut Fiber Cement Board In Ratios A

Trials	Depth/ Thickness of Rice Husks plywood (cm)	Width of the Rice Husks plywood (cm)	Length of the Rice Husks plywood (cm)	Mass of Load(kgf)	Modulus of Rupture (kgf/)
1	1	35	35	7	10.5
2	1	35	35	0	0
Mean					5.25

Note. Ratio A: (360g: 360g: 360g: 450g)

As seen in Table 2, the modulus of rupture in kgf/$cm^2$of ratio A is at 10.5 kgf/cm^2. This is because ratio A could not withstand the starting weight during the first flexural strength test. This gives us a mean of modulus of rupture equivalent to 10.5 kgf/cm^2. It is also observable that the maximum load that the rice husk and coconut fiber cement board can carry is at 7 kgf. Finally, the rupture modulus depends on the cement board's measurements and the maximum mass of load it can take. This result strongly implies that variation A cannot be a constructional board, neither a cement board nor a gypsum board, according to the American Society for Testing and Materials C1396 (ASTM International, 2014) and Indian Standard 14862 (2000).

Table 3. The Flexural Or Bending Strength Of Rice Husks And Coconut Fiber Cement Board In Ratios B

Trials	Depth/ Thickness of Rice Husks plywood (cm)	Width of the Rice Husks plywood (cm)	Length of the Rice Husks plywood (cm)	Mass of Load(kgf)	Modulus of Rupture (kgf/)
1	1	35	35	14	21
2	1	35	35	12	18
Mean					19.5

Note. Ratio B: (540g: 270g: 270g: 540g)

Table 3 shows the modulus of rupture for Ratio B. The modulus of rupture of ratio B ranges from 18 kgf/cm^2 to 21 kgf/cm^2 and has a mean of 19.5 kgf/cm^2. Meanwhile, the maximum load that the second ratio can carry ranges from 12kgf to 14kgf. It is also observable in the table that the lower the mass of the maximum load the cement board can carry, the lower the modulus of rupture, considering that the dimensions of each sample are the same.

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In comparing ratios A and B, ratio B is more vital than ratio A regarding its modulus of rupture. One aspect that affects their strength is their ratios. Ratio B has more adhesive in it than ratio A. This result strongly implies that variation B is not feasible enough compared to commercial cement board based on the Indian Standard 14862 (2000). However, according to the American Society for Testing and Materials C1396 (ASTM International, 2014), this variation is feasible to be comparable to a gypsum board used for wall and ceiling finishing.

Table 4. The Flexural Or Bending Strength Of Rice Husks And Coconut Fiber Cement Board In Ratios C

Trials	Depth/ Thickness of Rice Husks plywood (cm)	Width of the Rice Husks plywood (cm)	Length of the Rice Husks plywood (cm)	Mass of Load (kgf)	Modulus of Rupture (kgf/)
1	1	35	35	17	25.5
2	1	35	35	20	30
Mean					27.75

Note. Ratio C: (720g: 180g: 180g: 720g)

From the information from Table 4, the load mass is given in kgf and is 17 and 20 kgf for two different cases. The modulus of rupture is the measure of the strength of a material and is given as 25.5 and 30 kgf/cm^2 for the same two cases. The mean value of modulus rupture for the two cases is g7.75 kgf/cm^2. This information implies that variation C is not feasible enough when it is compared to commercial cement board with a minimum MOR of 71.38 kgf/cm^2(IS 14862, 2000), but the same with variation B, this variation can be recommended to be comparable to a gypsum board based from the American Society for Testing and Materials C1396 (ASTM International, 2014).

In comparing all the different variations regarding its modulus of rupture, ratio C is the strongest. One aspect that affected their strength is their variations, especially in their adhesives where variation C has the most adhesive(cement-water) in its variation. Samadhiya et al. (2017) found that adding cement to the concrete mix improved the compressive strength, flexural strength, and modulus elasticity of the composite material. With this, it can be inferred that the more adhesive a material is, the stronger it is.

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Table 5. Variation A, B And C Modulus Of Rupture Mean And Their Implication

Variation	Modulus of Rupture Mean	Interpretation
A	5.25	-
B	19.5	Gypsum Board
C	27.75	Gypsum Board

Table 5 shows the modulus of rupture mean of each variation in kilogram-force per centimeter squared and their implications according to the Indian and American Standards for construction boards regarding their flexural bending strength property, which was tested through a three-point bending test. Variation A has a MOR mean of 5.25 which does not meet the range in terms of flexural strength for either cement board which has a range of 40.79-224.34 nor gypsum board that has a MOR range of 15.3-24.47. While Variations B and C show a MOR mean of 19.5 and 27.75, which both can be under gypsum boards in terms of flexural strength, but neither B nor C meets the minimum MOR for a cement board, neither type A has a minimum MOR of 71.38 nor type B cement board has a minimum MOR of 40.79.

Table 6. The Significant Difference Between Ratio A, Ratio B, Ratio C And The Commercialized Cement Board In Terms Of Flexural Or Bending Strength

Comparison Groups	Count	Mean	Mean Difference	Lower	Upper	p-value
var_A	2	5.25				
- var_B	2	19.5	-14.25	-31.2497	2.749698	0.08620
- var_C	2	27.75	-22.5	-39.4997	-5.500302	0.01944
- Commercial	2	71.38	-66.13	-83.1297	-49.1303	0.00032
var_B						
	2	19.5				
- var_A	2	5.25	14.25	-2.749698	31.2497	0.08620
- var_C	2	27.75	-8.25	-25.2497	8.749699	0.32950
- Commercial	2	71.38	-51.88	-68.8797	-34.8803	0.00083
var_C	2	27.75				
- var_A	2	5.25	22.5	5.500302	39.4997	0.01944

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- var_B	2	19.5	8.25	-8.749699	25.2497	0.32950
- Commercial	2	71.38	-43.63	-60.6297	-26.6303	0.00166
Commercial	2	71.38				
- var_A	2	5.25	66.13	49.1303	83.1297	0.00032
- var_B	2	19.5	51.88	34.8803	68.8797	0.00083
- var_C	2	27.75	43.63	26.6303	60.6297	0.00166

Note. 95% Simultaneous Confidence Limits of the Difference
$\alpha = 0.05$, Error Term = S(A), DF = 4, MSE = 17.4375, Critical Value = 5.7572

Standard and commercialized fiber cement boards have stronger bending strength than the three ratios. According to the Indian Standard 14862 (2000), the minimum modulus rupture of a cement board for external application is 7Mpa or 71.38 kgf/cm^2, thus, this implies that the performance of the alternative cement boards in flexural strength is not enough to be part of the of the commercial cement boards in the market. It is recommended for the rice husk-coconut fiber cement board to be used for interior uses such as a gypsum board.

Table 7. The Significant Difference Between Ratio A, Ratio B, Ratio C And The Commercialized Cement Board In Terms Of Flexural Or Bending Strength

	Mean	df	t-Stat	P(T≤t) two tail
A	5.25	2	-12.5962	0.006244
B	19.5		-34.5867	0.000835
C	27.75		-19.3911	0.002649

Table 7 shows the t-test result of the bending strength of Ratio A, B and C compared to the standard bending strength value of 71.38. Two sample t-tests were used to test the hypothesis. The mean bending strength of ratio A is 5.25 kgf/cm^2, significantly lower than the standard (t_c= -12.596, $p < 0.05$). The mean bending strength of ratio B is 19.5 kgf/cm^2, significantly lower than the standard (t_c= -34.5867, $p < 0.05$). The mean bending strength of ratio C is 27.75 kgf/cm^2, significantly lower than the standard (t_c= -19.39, $p < 0.05$). This implies that the performance of the alternative rice husk-coconut fiber cement board in terms of flexural strength is not feasible enough compared to the commercialized cement board. Standard and commercialized cement boards have stronger bending strength than the three ratios. According to Indian Standard 14862 (2000), a cement board's bending strength ranges from 71.38 kgf/ to 183.55 kgf/, but according to ASTM International (2014), variations B and C can be recommended for a gypsum board which has a flexural strength range of 15.3-24.47 kgf/; thus, it suggests that the strength of the rice husk-coconut fiber cement board is not enough to be part of the standard strength of cement board. It is recommended for rice husk-coconut fiber cement board to be used for interior uses as a gypsum board, furniture component, or decorative support.

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Conclusion And Recommendation

In conclusion, this study investigated the feasibility of using rice husk-coconut fiber cement board as an alternative ingredient in constructing cement boards. The results obtained from the experiments indicate that while the rice husk-coconut fiber cement board may not be suitable as a direct replacement for commercial cement boards in terms of flexural strength, it can serve as a viable alternative for gypsum boards. Furthermore, ratio C, which exhibits superior performance, can be considered for further development and refinement to enhance its flexural strength in future studies. Additionally, among the three ratios (A, B, and C), ratio C demonstrates the best performance in flexural strength, surpassing ratios A and B. Ratio C exhibits higher bending strength and modulus of rupture compared to ratios A and B. This suggests that increasing the mixture's cement content will enhance the cement board's flexural strength. Thus, incorporating additional cement into the mixture can lead to an increase in the overall flexural strength of the board. Lastly, the hypothesis testing conducted in the study results in rejecting the null hypothesis (Ho) that there is no significant difference between the rice husk-coconut fiber cement board and the commercial cement board regarding bending strength. On the contrary, the alternative hypothesis (Ha) is accepted, indicating that there is indeed a significant difference between the two boards regarding their bending strength.

Recommendations are to be given in order for future researchers to better understand this research, along with the beneficiaries of said research. Firstly, the researchers recommend that the rice husk-coconut fiber cement board be used only for interior, indoor, or decoration purposes. Secondly, it is also recommended that future researchers conduct testing on other properties of alternative cement boards, such as their density, water absorption, dry heat test, hardness test, and other strength tests. Lastly, the researchers recommend that the Rice Husk-Coconut Fiber Cement Board is a possible alternative for writing boards.

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