Durability and Strength Property of Wastepaper Cement Board Reinforced with Steel Fiber

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Abstract*: The study investigates the development and performance Waste Paper Cement Boards (WPCBs) reinforced with 5% steel fiber as a sustainable and cost-effective alternative for house ceiling materials. It evaluates the mechanical and physical properties of WPCBs, including density, water absorption, and flexural strength based on varying proportions of cement and waste paper, as well as different curing durations of 7, 14, and 28 days, following ASTM C140 and ASTM C78/C78M standard. Three mix designs were examined: Sample 1 with 75% cement, 20% waste paper, and 5% steel fiber; Sample 2 with 47.5% cement, 47.5% waste paper, and 5% steel fiber; and Sample 3 with 20% cement, 75% waste paper, and 5% steel fiber. The results show that density increases with higher waste paper content, and water absorption is greater with higher cement content. Flexural strength is significantly affected by waste paper content and curing time, with Sample 1 achieving the highest strength of 20.37 MPa after 28 days, while Sample 3 exhibited the lowest at 9.765 MPa, representing a 40.3% decrease in strength from the 7th to the 28th curing day. The cost analysis of WPCBs revealed that they are more economical than traditional fiber cement boards, with a production cost of ₱15,261.56 compared to ₱45,956.25 for traditional FCBs. This results in a total savings of ₱30,694.69. WPCBs, with a 75% cement, 20% waste paper, and 5% steel fiber composition, offer a balance of strength, water resistance, and affordability, making them a viable and environmentally friendly construction material.

***Keywords*: cement board, wastepaper, steel fiber.**

1. Introduction

Innovations in construction have a substantial impact on the sustainability of communities and urban areas. A pressing concern is promoting environmental consciousness, particularly in construction industries, to develop eco-friendly materials [1]. Utilizing materials from existing resources and trash can have environmental advantages when used in construction components. The municipal solid waste is composed of 52.31% biodegradable, 27.78% is recyclable, and 17.98% is residual waste, which comprises plastics, paper and cardboard, metals, glass and textiles, leather, and rubber, 1.93% is categorized as "special waste" [2]. Waste paper, particularly cementitious matrices, has been utilized in construction materials to address environmental concerns by reducing paper disposal. Research has been conducted to improve the mechanical properties of composites, including compressive, tensile, and flexural strength.[3]. Paper, primarily made of cellulose fiber, is a common waste produced by the paper industry, which produces various products like printing, sanitary, newspapers, and packaging materials [4]. Researchers have utilized waste paper, a versatile, energy-efficient, and multi-recyclable material from various sources, to create a cement board due to its excellent insulating properties and its renewable origin. [1]. This waste material is sourced from households, companies, and stationery stores.

Fibers are increasingly being used as a replacement for traditional steel mesh in ground-bearing slabs due to their durability, slender nature, and ease of bending. Steel fibers are also being used in suspended ground floor slabs on piles to replace some or all reinforcement [5]. Fiber-reinforced cement-based products are widely used in construction for exterior finishing in residential, office, educational, banks, metro stations, rail stations, tunnels, bridges, and racks [6]. Steel, polymers, and cellulosic fibers are frequently utilized to strengthen cement-based products, which might vary from cement paste to mortar to concrete [7]. Incorporating the steel fiber into the waste paper cement board mixture increases the product strength.

Environmental sources, including offices, newspapers, and marketplaces, contribute to waste paper. Waste papers are a plentiful supply of cellulose and can be utilized for landfill purposes [8]. Waste papers can be transformed into construction materials through various engineering methods, addressing environmental concerns and ensuring dependable, eco-friendly products in industries like building, construction, and manufacturing [9]. Some researchers have looked into the possibilities of utilizing waste paper to manufacture cement boards that are environmentally friendly, low-cost, and lightweight [8]. Wastepaper is an abundant and eco-friendly raw material that can be transformed into lightweight, insulating construction materials by incorporating waste paper cellulose into concrete at specific levels, enhancing thermal insulation and density [8]

This study aimed to produce an environmentally friendly building material; a cement board made of waste paper reinforced with steel fiber. As a result of this study, it significantly affects the mechanical properties of the cement board. Moreover, this study determined the most economical design ratio of cement board. Thus, this study created a sustainable and ecologically friendly building material.

A. Conceptual Framework

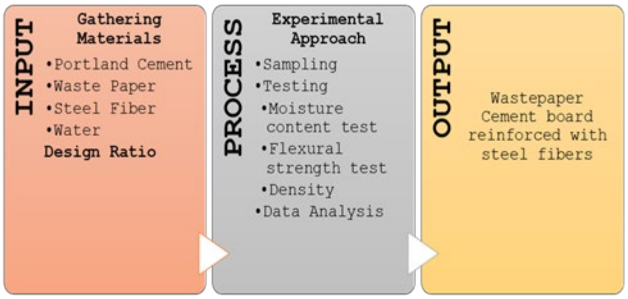

Fig. 1. Conceptual framework of the study

2. Introduction

Figure 1 illustrates the process of developing waste paper cement boards (WPCBs) reinforced with steel fiber using the Input-Process-Output (IPO) model. The input stage includes the essential materials—waste paper, Portland cement, steel fiber, and water—along with their specific design ratios. The process stage involves the experimental procedures such as material preparation, board casting, curing, and testing, which includes moisture content and flexural strength assessments. The output is the development of an eco-friendly, cost-effective waste paper cement board suitable for ceiling applications. This framework guides the systematic evaluation of WPCBs as a sustainable construction material.

A. Statement of the Problem

The study investigates the use of waste paper cement boards (WPCBs) reinforced with steel fiber as an eco-friendly ceiling material to address the increasing paper waste problem in schools, offices, and businesses. The research addresses the following specific objectives:

1. To evaluate the physical and mechanical properties of waste paper cement boards reinforced with steel fiber, specifically:
   - *Physical properties*: texture, weight, color
   - *Mechanical properties*: density, water absorption, flexural strength
2. To assess the advantages and disadvantages of waste paper cement boards in terms of:
   - Material costs
   - Production costs
3. To identify the most economical design ratio for developing waste paper cement boards reinforced with steel fiber, ensuring optimal performance in both strength and cost efficiency.

The findings of this study aim to contribute to the development of sustainable construction materials by promoting the reuse of waste paper and reducing the environmental impact of traditional cement board production.

B. Scope and Limitation of the Study

The study explores the use of recycled waste paper in creating cement boards reinforced with steel fiber for sustainable construction, specifically for ceilings. The research optimizes the mixture of waste paper, Portland cement, steel fiber, and water to produce durable, eco-friendly cement boards. The study utilized a flexural testing machine to evaluate the mechanical strength of boards post-curing, with flexural strength as the primary performance metric, over specific curing periods to assess the impact of curing time on the final product's strength and durability.

The scope of the study is limited to the development and performance evaluation of waste paper cement boards. Data collection was confined to the results obtained from laboratory testing procedures, specifically flexural strength analysis. Limitations include variability in the quality of recycled paper materials, which may affect the consistency, mechanical properties, and scalability of the cement boards produced.

3. Review of Related Literature

This chapter presents a comprehensive review of literature on waste paper cement boards (WPCBs) reinforced with steel fiber, exploring their potential as sustainable, cost-efficient alternatives to conventional construction materials. The review draws on sources from academic databases including Google Scholar, ResearchGate, and ScienceDirect, focusing on physical and mechanical performance and the economic feasibility of utilizing recycled paper and steel fiber in cement board production.

A. Properties and Advantages of Waste Paper Cement Boards

Paper waste is one of the most abundant recyclable materials and has been identified as a viable raw material in concrete and mortar applications [15]. Classified as municipal waste, it is commonly sourced from households, businesses, schools, and offices [1]. The daily paper waste generated in schools through discarded worksheets, test papers, and printing errors contributes significantly to the waste stream [4].

Waste paper offers several benefits as a construction material: it is lightweight, flexible, cost-effective, recyclable, and has good insulation properties. These characteristics make it a promising alternative to conventional aggregates and fillers in concrete mixes [16]. Cement boards incorporating waste paper have shown improved ductility and reduced brittleness compared to traditional boards [1].

A cement board is typically a composite material made of cement and lignocellulosic biomass, including recycled paper, offering fire resistance, termite resistance, and durability [12]. Fiber Cement Boards (FCBs) are widely used in construction as substitutes for wood-based materials such as plywood and oriented strand boards. Their applications include cladding, interior wall partitions, soffit linings, and balcony panels [18].

B. Role of Steel Fiber in Cement Board Performance

To enhance structural performance, researchers have studied the addition of various fibers to cementitious composites. Steel fiber has emerged as one of the most effective reinforcing materials, especially for improving crack resistance and toughness [26]. The incorporation of reinforcing fibers not only increases tensile and flexural strength but also improves fracture toughness by mitigating stress concentrations at crack tips [25].

Research shows that stranded steel fibers, in particular, deliver superior mechanical characteristics compared to straight or hooked-end fibers at equal content levels [28]. Steel fibers enhance the ductility and shock resistance of concrete, making it more suitable for use in high-impact areas such as roads and industrial flooring [30].

Although the increase in compressive strength is minimal, steel fibers contribute to an increase in compressive strain capacity at peak loads, leading to better load distribution and energy absorption [29]. This makes them particularly useful in applications requiring impact resistance and long-term durability.

Table 1
Challenges in Using Fiber as reinforcement in cement Board

Citation	Challenges
[31], [32],[7], [10]	Availability of initial data
[11], [21]	Suitable blending proportion and mixing ratio
[33], [28], [34], [9], [17]	Used simplified and detailed approaches
[22], [23], [24]	Enhancing the mechanical properties (long-term toughness and durability)
[22]	Consistency of the mixture

C. Feasibility and Limitations of Using Waste Paper in Cement Composites

Waste paper cement boards are a sustainable solution for reducing landfill waste and promoting recycling in the construction industry, thereby reducing reliance on virgin materials like cement and timber.[3]. In addition, using paper-based composites can lessen deforestation and help preserve natural resources [9].

Despite their advantages, WPCBs face limitations, primarily related to material variability. Paper from different sources may differ in fiber content, ink, and contaminants, affecting the uniformity and mechanical performance of the cement mix [12]. Ensuring a proper mix design and processing method is essential to maintain consistency and durability.

The study examines the flexural strength, density, and water absorption properties of WPCBs reinforced with steel fiber, with a focus on curing time. It recommends further research on fire resistance, thermal insulation, and WPCBs' behavior in real-world environmental conditions.

D. Environmental and Economic Impact

The construction industry is a major consumer of resources and a key contributor to carbon emissions, especially through cement production. Utilizing waste paper and replacing a portion of cement content reduces the carbon footprint of construction activities [9].

Economically, WPCBs present a viable option for communities with limited financial resources. Compared to fiber cement boards, the cost of producing WPCBs is significantly lower. This cost efficiency makes them ideal for low-income housing and public infrastructure projects, where material savings can translate to broader community benefits [17].

In conclusion, the integration of waste paper and steel fiber into cement board production offers a sustainable alternative with promising mechanical performance and cost benefits. By turning paper waste into useful building materials, the construction industry can contribute to waste reduction, resource conservation, and environmental sustainability.

E. Research Gaps

There are several research gaps identified in the development of cement boards reinforced with steel fibers. One key area is the lack of studies investigating the use of steel fiber in concrete mixes for cement board production. Although various studies have explored the use of additives such as silica, coco fiber, and waste paper to improve cement board properties, no study has yet established an optimal mix ratio for incorporating steel fiber [8]. The study uses trial proportions to determine the best mix for cement boards reinforced with steel fibers, as the exact proportions remain unknown, requiring careful assessment of physical properties like density and mechanical strength.

Various investigations have revealed significant challenges in the development of fiber-reinforced cement boards. Some of these challenges are outlined in Table 1, which shows key research gaps and challenges faced by previous researchers.

One critical research gap identified is the determination of the most suitable blending proportion and mixing ratio for the fiber-reinforced cement boards. Achieving the right mix is crucial to avoid irregularities and ensure the desired strength, durability, and other properties. More studies are needed to assess the long-term toughness and endurance of these concrete types, as this will help increase confidence in their use in the building industry. Additionally, the consistency of the mixture is important to guarantee the desired quality of the boards. The research also highlights the need for a longer curing period to ensure the maximum strength of cement fiber boards [22].

In conclusion, further research is required to fill these knowledge gaps and improve the application of steel fiber in cement boards, specifically focusing on the mixing proportions, long-term mechanical properties, and consistency of the mixture. Addressing these gaps will enhance the performance and reliability of these eco-friendly construction materials.

4. Methodology

A. Flowchart of Research Design

The Process Flowchart shown in Figure 2 illustrates the sequential steps necessary to accomplish a certain activity or reach a desired result. The study involves evaluating material requirements and their extent. Conducting a thorough critical analysis of current knowledge from various online sources is essential for this research. A physical experimental investigation was conducted to examine the systematic method through data collection. The study's objective is assessed to see if it was accomplished after analyzing the results. The graphic illustrates the whole process of assessing the study results, including the write-up and research findings.

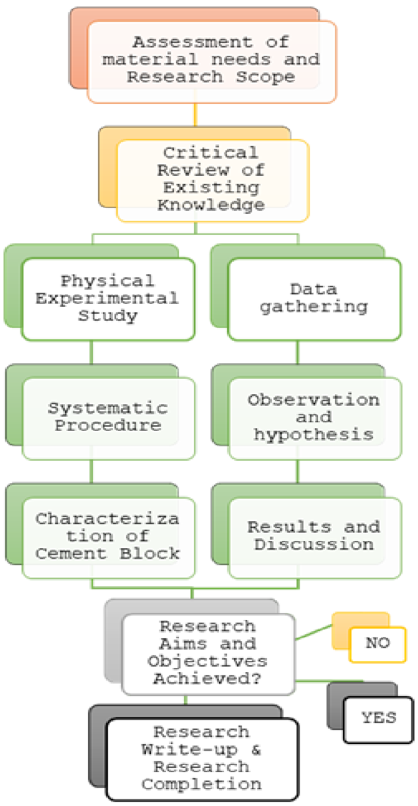

Fig. 2. Flowchart

B. Material Requirement

The following data shows the materials used to produce a wastepaper cement board reinforced with steel fiber.

According to the mixing ratio and blending proportion shown below, the amount of the materials (cement, wastepaper, and steel fiber) used to produce each board sample with the dimensions 350 × 350 mm x 10 mm were calculated, poured out on a weighing balance, and added to the mixing bowl [8], [23], [24]:

- *Blending/paper type*: Wastepaper 100%
- *Total weight of the material*: 1350 grams

Size to Weight Formula for Rectangular was used to determine the total weight of the specimen.

W=lwh x density of concrete block

In terms of meters;

$l = 350mm$

$w = 350mm$

$h = 10mm$

Density of lightweight concrete $= 0.0011\ g/mm^3$

$W = 350mm \times 350mm \times 10mm \times 0.0011\ g/mm^3$

W = 1,347.5g = 1,350g

The weights of all the materials were varied to produce three different board samples as determined by the board mix ratio. The quantity of material used was based on the percentage weight of the material in relation to the weight of cement. The amount of water was calculated using the equation below and weighed properly; each of the materials (cement, paper, and steel fiber) calculated was put in polythene bags [8], [23], [24]

$$\text{Amount of Water} = 0.60C + W\,(0.30 - MC)$$

Where;

C = Cement weight,

W = Weight of paper + steel fiber,

MC = Moisture Content

The weights required to produce the Cement Board (CB) from paper and steel fiber are shown in Table 3. Some other factors that are constant and used in this research are as follows:

a) Board thickness = 10 mm
b) Moisture content = 6%
c) Board size = 350 mm × 350 mm × 10 mm

- Cement/paper/steel fiber mixing ratio:

Mixing Ratio Equation

$$W = \text{Total weight of material} \times \%\ \text{of raw material}$$

Table 2
Materials used in waste paper cement board

	Materials	Specifications
1.	Waste Paper	These are the papers that have been used and discarded. School paper waste such as printing errors, scratch papers, and old paperwork. Old newspaper waste Disposed company documents It was collected from areas with abundant paper waste including schools, offices, and businesses
2.	Cement	It is an important building material in today's construction world. In this study, Ordinary Portland cement of 53 grade was used to prepare the wastepaper fibrous cement.
3.	Steel Fiber	Steel fibers are small, discontinuous strips of specifically produced steel. Their incorporation into concrete increases its mechanical qualities greatly. Type: HE125 Shape: Hook end Sizes: 0.5mm x 30mm length
4.	Water	Tap water

Table 3
Weights required to produce cement board

Design Ratio No.	Materials Proportion Cem:Pap:Sf(%)	Weight of Cement (g)	Weight of paper (g)	Weight of Steel Fiber (g)	Weight of Water (g)
1	75:20:5	1012.5	270	67.5	688.5
2	47.5:47.5:5	641.25	641.25	67.5	554.85
3	20:75:5	270	1012.5	67.5	421.2

C. Specimen Details

The waste paper cement board specimens were 350 mm x 350 mm square, about 10mm thick, with a weight of approximately 1,350g, made of waste paper, cement, and steel fiber. Three different design mix ratios were created to investigate how different material compositions affected board performance: design ratio 1 (75% cement, 20% paper, 5% steel fiber), design ratio 2 (47.5% cement, 47.5% paper, 5% steel fiber), and design ratio 3 (20% cement, 75% paper, 5% steel fiber). To guarantee uniformity in testing, every board is manufactured in a standard form and cured under the same conditions. The three designs allow comparative analysis of strength, durability, and moisture resistance across varying paper quantities.

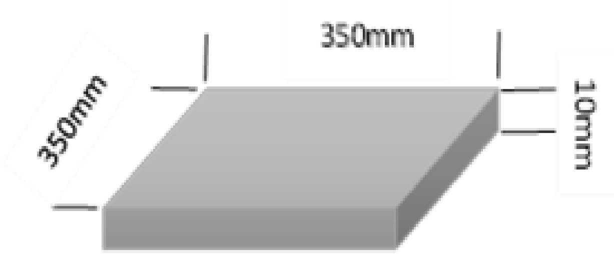

Fig. 3. Wastepaper cement board reinforced with steel fiber

D. Laboratory Experiment

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

Density. The density of the specimens was measured using a standard laboratory procedure. The specimens' mass was measured after being put in a laboratory setting at room temperature for one day. The specimens' volume was determined by submerging them in water and measuring the displaced water. The quotient of mass divided by volume was regarded as the density of the specimens.

Water Absorption Tests. The dry weight (i.e. weight before soaking in water) of the specimens for the water absorption test was recorded as the beginning weight, and they were then horizontally stacked in a container filled with distilled cold water at 20°C. The test specimens were immersed in water for 1 hour before being dried with a piece of cloth to eliminate excess water before being weighed on a scale. Then oven dry for about 115°c for 24hrs.

The readings for water absorption were obtained from the expression:

$$WA(\%) = \left(\frac{final\ weight - initial\ weight}{initial\ weight}\right) \times 10$$

Flexural Strength Test. To determine the flexural strength of the specimen flexural testing machine was utilized using Control Model 50-C1500/1 High Stiffness Flexural Frame, 200 kn cap. SIMPLEX. Flexural strength is one of the most important mechanical property of cement boards which has pointed out by all relevant standards. The specimens were subjected to flexure test and will be tested after 7, 14, 28 day of curing accordingly, deflection and load were recorded in all stages of loading.

E. Description of Research Instrument Used

In this study, the researcher will use pie chart, graphs and excel to evaluate all the data developed through multiple approaches, including experimentation, observation, and testing. The researchers will develop an economical and environmentally friendly concrete board from waste paper. The researcher's experiment was noted for the recommendation for the next and future studies

5. Result and Discussion

A. Density Test of Waste Paper CB

The 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 7,14, and 28 days of curing.

The test involved weighing the saturated weight, immersed weight, and oven-dry weight, as shown in the figure. Additionally, volume measurements were recorded to calculate the density using the formula provided in the density measurement section.

The density of the waste paper cement board with a mixture of 75% of cement, 20% waste paper and 5% of steel fiber. Based on the graph indicated, the sample 1(28 days) has a highest density of 401.36 kg/m³ and the lowest density is sample 1(14 days) around 353.63 kg/m³.

The density of other examples of the waste paper cement board with a mixture of 47.50% of cement,47.50% waste paper and 5% of steel fiber. There are 3 samples in the graph, the sample 2(28 days) has the lowest density around 432.12 kg/m³ and the sample with the highest density is sample 2(7 days) with a value of 497.13 kg/m³.

The last sample of the waste paper cement board with a mixture of 20% of cement,75% waste paper and 5% of steel fiber. There are 3 samples in the graph, the sample 3(7 days) has the highest density around 661.93 kg/m³, and the two remaining samples have a density of 631.93 kg/m³(28 days) and 649.77 kg/m³ (14 days).

The density measurement varies depending on the curing days.

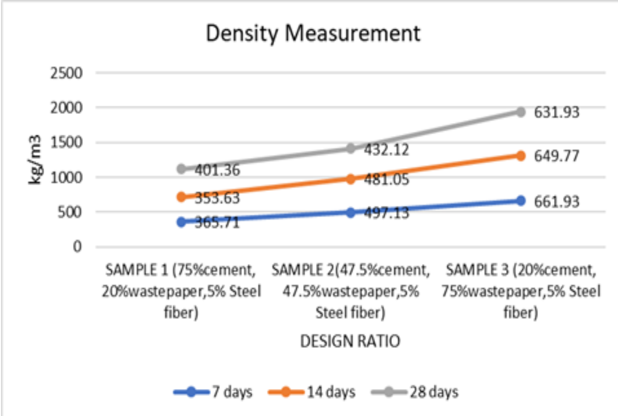

Fig. 4. Density measurement result

B. *Water Absorption Test of Waste Paper CB*

The figure 5 presents the results gathered from the water absorption test. Following the established standards of ASTM C140, the water absorption test procedure was properly carried out, and the selected specimen was oven-dried after 7,14, and 28 days of curing for 24 hrs.

From the results obtained in Fig. 5 for Water absorption (WA) properties, water resistance was lowest in boards made from waste paper cement board with a mixture of 75% of cement, 20% waste paper and 5% of steel fiber while water resistance was highest when waste paper cement board with a mixture of 20% of cement, 75% waste paper and 5% of steel fiber/ It was also noticed that there is a general decrease in WA depending on the curing days. The decrease in the WA could be attributed to the facts that as the cement content increased many void spaces are filled and this assist in the possibility of getting a thorough and homogenous mix of the cement bonded board. This phenomenon can also be attributed to compatibility between the cement and fiber used in this study which brought about good bond formation, less void spaces and reduction in the rate of water absorption.

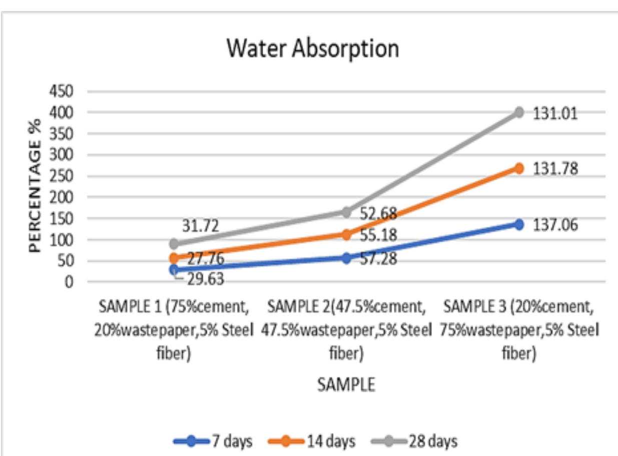

Fig. 5. Water absorption test result

C. *Flexural Test of Waste Paper CB*

Considering the properties of cement and waste paper, reinforcing it with steel fiber is an environmentally sustainable approach that helps reduce pollution from traditional cement board production, aligning with a global movement toward greener construction materials. This highlights the value of research, particularly in evaluating the effectiveness of steel fiber as a reinforcement material. The addition of steel fiber to cement and waste paper percentage 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.

In summary, the data indicate that the flexural strength of the Waste Paper Cement Board is significantly affected by the proportion of paper and the duration of the curing period. Sample 1, with 20% paper, achieved the highest flexural strength after 28 days at 20.37 MPa, with a mean of 18.432 MPa. Sample 2, with 47.5% paper, showed moderate strength gains, reaching 16.829 MPa. Sample 3, with the highest paper content, exhibited a consistent linear decrease in strength across all curing periods, with a final strength of 9.765 MPa, representing a 30.9% decrease from the 7th to the 14th curing day and 40.3% decrease from the 7th to the 28th curing day. The data suggest that the flexural strength of Waste Paper Cement Board is significantly impacted by the paper content and curing duration. Strength decreases with increasing paper content; the largest percentage of paper (47.5%) exhibits steady strength loss with time. After 28 days, Sample 1, which contained 20% paper, had the maximum flexural strength, suggesting that the ideal paper-to-cement ratio for strength is balanced. Longer curing times appear to reduce the strength of boards with more paper, highlighting how crucial it is to carefully regulate the amount of paper and the curing time for best results.

Table 4
Flexural strength test result

SPECIMEN	Sample Composition		7 DAYS		14 DAYS		28 DAYS	
			Strength(Mpa	Average	Strength(Mpa)	Average	Strength(Mpa)	Average
1	75% - Cement	S- 1A	8.40	8.433	11.30	13.193	20.37	18.432
	20% - paper	S- 1B	8.00		15.68		16.80	
	5% - Steel fiber	S- 1C	8.90		12.60		18.13	
2	47.5% Cement	S- 2A	6.40	15.083	9.60	13.343	6.44	16.829
	47.5% paper	S- 2B	27.60		13.09		11.39	
	5% - Steel fiber	S- 2C	11.25		17.34		32.65	
3	75% - paper	S- 3A	16.94	16.352	10.00	11.300	13.40	9.765
	20% - cement	S- 3B	13.75		12.20		9.58	
	5% - Steel fiber	S- 3C	18.37		11.70		6.31	

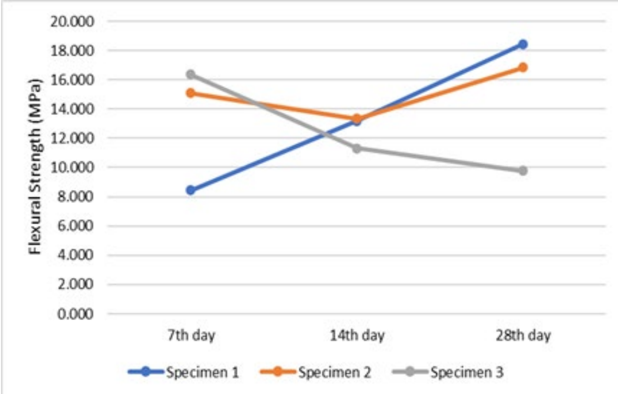

Fig. 6. Average flexural strength test result

D. *Cost Analysis*

This section presents a comparative cost analysis of using Waste Paper Cement Boards (WPCBs) versus Fiber Cement Boards (FCBs) for a 100-square-meter ceiling construction. Based on the standard board dimensions and total area required, it was determined that 817 boards would be needed for the project. To determine the cost-effectiveness of WPCBs, the price per board was calculated based on a sample cost for producing 9 boards, which totaled 168.13 pesos.

Fig. 7. Flexural strength test using third point loading

Table 5
Unit cost of 9 pcs cement board (specimen 2)

A. MATERIALS:CONST	UNIT	QUANTITY	UNIT COST	TOTAL COST
Cement	kg	9.1125	6.525	59.46
Steel Fiber	kg	0.6075	130	78.98
Paper Pulp				0.00
Sub total(A)				138.43
B. LABOR COST	No. of Per	Total Hours	HOURLY RA	TOTAL COST
Skilled Labor	1	0.33	90	29.7
Sub total(B)				29.7
Total Direct Cost				168.13

Dividing this total by the number of boards yielded an approximate cost of 18.68 pesos per WPCB. Using this value, the total cost of producing 817 WPCBs was calculated at 15,261.56 pesos. In comparison, the cost of one FCB was found to be 56.25 pesos, resulting in a total of 45,956.25 pesos for the same number of boards. This comparison clearly shows a significant price advantage in using WPCBs, with a total savings of 30,694.69 pesos when compared to FCBs. These savings make WPCBs a highly cost-effective alternative, especially for low-budget or resource-limited construction projects.

The study also evaluated the viability of using waste paper cement boards reinforced with steel fiber as a low-cost ceiling material. The findings not only demonstrated compatibility in terms of material performance but also highlighted practical methods for producing WPCBs using waste paper and cement mixtures. This approach promotes environmental sustainability while significantly reducing construction costs without compromising structural integrity.

6. Conclusion

This study investigates the use of waste paper cement board reinforced with steel fiber as an environmentally friendly and sustainable house ceiling material. The research demonstrates that the mix of waste paper in the cement board affects the mechanical properties of the materials, particularly the flexural strength, density and water absorption. Therefore, the research concluded that:

- The results indicate that the density of the wastepaper cement board varies depends on curing days and paper pulp content. As the amount of paper increased in the mixture, the density significantly increases.
- Increasing the percentage of the wastepaper reduce the flexural strength of the board.
- Water resistance was lowest in boards with higher percentage of paper. The higher the amount of cement causing the lower the water absorption.
- The cost analysis highlighted that waste paper cement board is significantly more affordable than conventional fiber cement board, making them a viable alternative in communities with limited financial resources.

7. Recommendations

This study reinforces the potential of waste paper cement board reinforced with steel fiber as an affordable, sustainable, and ecologically friendly building material. Thus, utilizing wastepaper helps address the challenge of disposing large amount of paper.

- Further research could focus on long-term durability assessments of cement board
- Environmental impact analysis of these cement boards is recommended to investigates in further study.
- Further investigation of more efficient utilization of

waste paper and steel fiber

8. Acknowledgment

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The Researchers

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