UTILIZATION OF CHICKEN FEATHER ASH AS PARTIAL REPLACEMENT FOR CEMENT WITH COCONUT SHELLS AS COARSE AGGREGATES.

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UTILIZATION OF CHICKEN FEATHER ASH AS PARTIAL REPLACEMENT FOR CEMENT WITH COCONUT SHELLS AS COARSE AGGREGATES

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Abstract: *This study examines chicken feather ash (CFA) as a partial cement replacement and coconut shells (CS) as coarse aggregate substitutes to enhance concrete performance and sustainability. Phase 1 identified 2.5% CFA as the optimal replacement, improving compressive strength, workability, and flexural strength. Phase 2 tested concrete with 2.5% CFA and varying CS levels (0%, 10%, 20%, 30%) per ASTM standards. While CFA improved strength and workability, higher CS content reduced compressive strength. The study concludes that 2.5% CFA without CS substitution offers the best balance for moderate-load structures. Future research should explore CFA-based concrete durability in different environments.*

Keywords: Chicken feather ash; Coconut shells; water-cement ratio;

1. INTRODUCTION

The rapid urbanization and modernization across the globe have significantly increased the demand for cement, a key component in the production of concrete. Concrete is made by combining cement, water, and coarse aggregates, with cement being the primary binding agent that holds the mixture together. However, the environmental consequences of cement production are substantial. Cement manufacturing is highly energy-intensive, producing significant amounts of CO2, a major contributor to global greenhouse gas emissions [1]. This environmental impact has sparked global efforts to find alternative materials that can reduce the carbon footprint of concrete production. This shift toward sustainability aligns with the growing focus on the circular economy, leading to an increased interest in alternative binders that use waste materials and produce fewer emissions [2].

As the concrete mix also relies on coarse aggregates for both volume and strength, the environmental challenges extend beyond cement. Coarse aggregates, traditionally sourced through practices such as quarrying and dredging, contribute to habitat destruction, noise pollution, and ecosystem damage [3]. The extraction of natural aggregates also exacerbates resource depletion, necessitating the development of sustainable alternatives. In this context, the construction industry has been exploring the use of waste materials as substitutes for both cement and aggregates. According to Katare and Madurwar (2018) [4], leveraging locally sourced, renewable materials can provide a solution to meet the increasing demand for construction materials while reducing environmental degradation.

The growing emphasis on sustainability in the construction industry has driven the exploration of agricultural and industrial byproducts as alternative concrete components. Among the various waste materials, poultry feathers have gained attention due to their potential for sustainable waste management. Poultry processing facilities generate billions of kilograms of chicken feathers annually, a large portion of which is typically disposed of through incineration or landfilling [5]. However, these feathers are primarily composed of keratin, a durable protein with potential uses in reinforcing materials like concrete. Yet, the commercial demand for these fibers remains limited, contributing to the environmental challenges posed by their disposal [6]. In addition, studies have explored the use of other poultry-related byproducts, such as poultry sludge, as partial cement replacements, highlighting the potential of poultry waste in improving the sustainability of concrete [7].

Similarly, coconut waste, particularly coconut shells, has been recognized as a promising resource for concrete production. The Philippines, being one of the world's largest producers of coconut products, generates substantial amounts of coconut waste each year. Coconut shells, rich in cellulose, lignin, and other compounds, offer several advantages when incorporated into concrete. Cellulose provides strength and stability to the fibers, while lignin contributes flexibility, water resistance, and fungal resistance. These properties help prevent debonding during cracking, improving concrete's durability and lifespan [8]. Despite their potential, coconut shells are often discarded or burned, leading to environmental pollution and health hazards [9].

This study aims to explore the potential of combining chicken feathers and coconut shells in concrete production. By partially replacing cement with chicken feather ash and coarse aggregates with coconut shells, the research seeks to evaluate the workability, compressive strength, and split-tensile strength of the resulting concrete mixtures. The goal is to identify a sustainable and cost-effective solution for concrete production that reduces waste, mitigates environmental impact, and maintains or enhances concrete performance. Such research contributes to the growing body of knowledge on sustainable construction practices, particularly in regions like the Philippines, where both poultry and coconut industries are prominent.

2. MATERIALS

The study followed the standardized procedures outlined by the American Society for Testing and Materials (ASTM) for assessing the mechanical properties of the specimens. Each test utilized molds of specific shapes and dimensions as prescribed by relevant ASTM standards. That is, a Digi Mortar Mixer, 50mm x 50mm Phenolic Board Molds, Universal Testing Machine (UTM), UNIFRAME tester, Half Bagger Concrete Mixer, 100 mm diameter and 200 mm length Cylindrical Molds, and 150 mm x 150 mm x 500 mm Flexural Beam Molds. The materials and equipment used included a mixing bowl, brush, tamper, flow table (in accordance with ASTM C230), hydraulic cement, graded standard sand, and precision weighing tools. Mechanical testing was conducted using the Universal Testing Machine (UTM) available in the laboratory. These materials played a crucial role in the preparation, casting, and testing of the concrete specimens during the study. The Digi Mortar Mixer provided uniform mixing, the molds facilitated the casting of samples in specified shapes and dimensions, and the Universal Testing Machine was used to evaluate the compressive and split tensile strengths of the concrete.

3. METHODS

An experimental research design was adopted for this study to ensure a systematic and controlled investigation of the effects of material substitutions on mortar and concrete properties. This approach enabled the precise testing of hypotheses and the identification of causal relationships between the use of chicken feather ash (CFA) and coconut shells (CS) and the resulting mechanical performance of mortar and concrete. By using this design, the study was able to comprehensively assess how these sustainable materials influence the workability, compressive strength, flexural strength, and split tensile strength of mortar and concrete mixes. The methodology involved a two-phase experimental approach. Phase 1 tested mortar mixes with varying CFA contents (0%, 2.5%, 5%, and 7.5%) to determine the optimal percentage based on compressive strength, workability, and flexural strength. The 2.5% CFA mix performed best and was used in Phase 2, which evaluated concrete samples incorporating 2.5% CFA and different levels of CS replacement (0%, 10%, 20%, and 30%) for coarse aggregates.

3.1 Phase 1: Determining the Most Desirable Percentage of Chicken Feather Ash

The research methodology began with the collection and preparation of chicken feather ash (CFA) and coconut shells (CS). Chicken feathers were obtained from May Harvest Corporation in Santa Maria, Bulacan, Philippines. Following Amah's (2021) [10] procedure, the feathers were washed, sun-dried for seven days, burned in an open vessel, then oven-dried for 24 hours to remove moisture. The resulting ash was ground and sieved according to ASTM C33 standards before being stored for use.

In the initial phase, various mortar mixtures were tested for mechanical properties, including workability, compressive strength, and flexural strength, to determine the optimal CFA replacement level. Mortar mixes with 0%, 2.5%, 5%, and 7.5% CFA were prepared. Workability was assessed using a flow table test (ASTM C230). Compressive strength tests (ASTM C109) were conducted after curing for 7 and 28 days, with 36 samples tested. The mix with the highest compressive strength was selected for further study. Lastly, a flexural strength test was performed using a UNIFRAME tester following ASTM D790 standards.

Table 1.Summary on Number of Specimens for Phase 1

Types of Tests	Percent CFA%	No. of Trials	Curing Time (Days)	No. of Specimens
Compressive	0	5	7, 28	10
Compressive	2.5	5	7, 28	10
Compressive	5	5	7, 28	10
Compressive	7.5	5	7, 28	10
Flexural	0	5	7, 28	10
Flexural	2.5	5	7, 28	10
Flexural	5	5	7, 28	10
Flexural	7.5	5	7, 28	10
Slump	0	N/A	N/A	N/A
Slump	2.5	N/A	N/A	N/A
Slump	5	N/A	N/A	N/A
Slump	7.5	N/A	N/A	N/A
TOTAL				**80**

(a) (b)

Fig. 1. (a) Compressive Strength Test of Mortar and (b) Flexural Strength Test of Mortar

3.2 Phase 2: Utilizing Most Desirable Percentage on Concrete and Testing

Coconut shells were collected from a farmhouse in San Juan, Batangas, then washed to remove impurities and sun-dried for seven days. The dried shells were crushed into pieces, ensuring they passed through a 4-inch sieve but were retained on a #4 sieve to meet size requirements for coarse aggregates.

The second phase of the study evaluated concrete mixes incorporating 2.5% chicken feather ash (CFA), the

optimal replacement level determined in Phase 1, with varying coconut shell (CS) replacements for coarse aggregates at 0%, 10%, 20%, and 30%. A concrete mix design was developed, and concrete specimens were produced accordingly.
Workability was assessed using the slump test (ASTM C143). After curing for 7 and 28 days, compressive strength was tested per ASTM C39, and split-tensile strength was also measured. A total of 100 samples were prepared, evenly distributed for compressive and split-tensile strength testing.

Table 2.Summary on Number of Specimens for Phase 2

Types of Test	CFA%	CS%	No.of Trials	Curing Time (days)	No.of Specimens
Compressive	0	0	5	7, 28	10
Compressive	2.5	0	5	7,28	10
Compressive	2.5	10	5	7, 28	10
Compressive	2.5	20	5	7, 28	10
Compressive	2.5	30	5	7, 28	10
Split-Tensile	0	0	5	7, 28	10
Split-Tensile	2.5	0	5	7,28	10
Split-Tensile	2.5	10	5	7, 28	10
Split-Tensile	2.5	20	5	7, 28	10
Split-Tensile	2.5	30	5	7, 28	10
Slump	0	0	N/A	N/A	N/A
Slump	2.5	0	N/A	N/A	N/A
Slump	2.5	10	N/A	N/A	N/A
Slump	2.5	20	N/A	N/A	N/A
Slump	2.5	30	N/A	N/A	N/A
TOTAL					**100**


(a) (b)

Fig. 2. (a) Compressive Strength Test of Concrete and (b) Split-Tensile Strength Test of Concrete

A total of 180 specimens were produced for the study. In Phase 1, 100 mortar specimens were created with varying percentages of chicken feather ash (CFA) as a partial cement replacement. In Phase 2, the optimal CFA replacement (2.5%) was incorporated into concrete mixtures with different coconut shell (CS) replacement levels for coarse aggregates, resulting in 80 concrete specimens.

Table 3. Summary of Total Number of Specimens

Phase	Number of Specimens
1 (Mortar)	100
2 (Concrete)	80
TOTAL	**180**

3.3 Concrete Mix Design

The study developed a concrete mix design to assess the effects of replacing coarse aggregates with coconut shells and cement with chicken feather ash (CFA) on concrete properties. The mix design followed ASTM standards to ensure consistency in preparation and testing. A 20-liter batch volume was used, incorporating varying proportions of coconut shells while maintaining a constant CFA percentage.
The concrete mixtures were prepared by keeping the water and fine aggregate (F.A.) content constant while adjusting the weights of coconut shells and CFA. The cement content was slightly reduced to accommodate a 2.5% CFA replacement by weight. Coconut shells were introduced as coarse aggregate (C.A.) replacements at 0%, 10%, 20%, and 30% proportions.
A table summarizing the wet weights of materials used in each mix variant follows.

Table 4. Summarized Wet Weight (20-Liter) 12 Samples

%	CS%	0	0	10	20	30
	CFA%	0	0.25	0.25	0.25	0.25
Weight (kg)	Cement	7.19	7.01	7.01	7.01	7.01
	Water	3.93	3.93	3.93	3.93	3.93
	C.A.	20.59	20.59	18.53	16.47	14.41
	F.A.	16.23	16.23	16.23	16.23	16.23
	CFA	0	0.18	0.18	0.18	0.18
	CS	0	0	2.06	4.12	6.18

Table 4 presents the weights of each component per mix, adjusted to achieve the targeted percentages of coconut shells and chicken feather ash while maintaining a consistent batch volume of 20 liters. These adjustments ensured accurate evaluation of workability, compressive strength, and tensile strength as part of the experimental analysis.

3.4 Statistical Analysis

The collected data on compressive strength were analyzed by comparing the mean and median values of each setup. This approach allowed a comparative analysis between the control group (standard concrete) and the experimental group (concrete with chicken feather ash and coconut shells). In addition, an ANOVA with post-hoc Tukey was conducted on the obtained values of workability of concrete to determine a difference among the setups. This was also conducted on the different setups when testing their compressive strengths.

4. RESULTS AND DISCUSSION

This section presents the analysis of the mechanical properties of the mortar and concrete with chicken feather ash as a partial cement substitute and coconut shells as partial replacement for coarse aggregates. That is, experimental data are compared with control samples, and graphs illustrate the effects of these substitutions on the material properties. A detailed discussion follows, highlighting performance variations and their implications.

4.1 Mortar Mix with Chicken Feather Ash as Partial Replacement for Cement

4.1.1 Slump Test

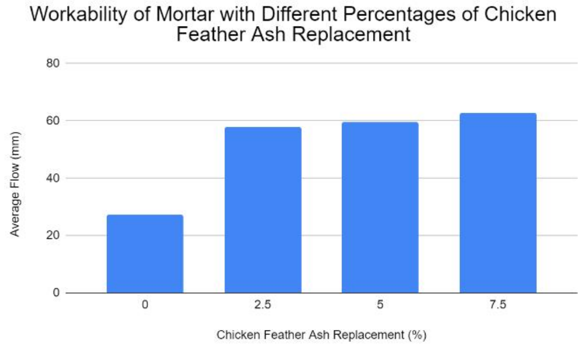


Fig. 1. Workability of Mortar

The graph shows the effect of chicken feather ash (CFA) on mortar workability, tested according to ASTM C143. The x-axis represents CFA replacement levels (0% to 7.5%), while the y-axis measures average flow in millimeters. At 0% CFA, the mortar had the lowest workability (27.21 mm). As CFA content increased, workability improved, with 2.5% replacement reaching 57.91 mm, 5% at 59.5 mm, and 7.5% peaking at 62.76 mm. This trend indicates that higher CFA percentages enhance mortar workability, likely due to its fine particles or pozzolanic properties, which improve fluidity and consistency.

4.1.2 Compressive Strength

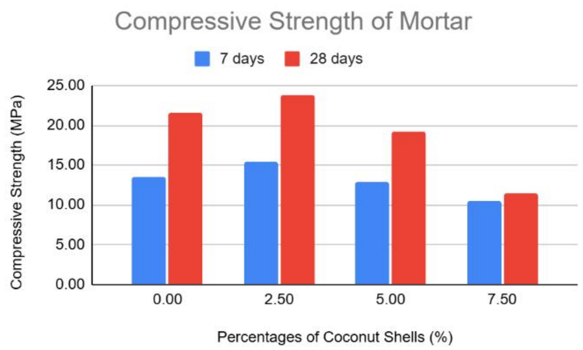


Fig. 2. Compressive Strength of Mortar

The analysis of compressive strength across different curing periods and CFA replacement levels showed that a 2.5% substitution consistently enhanced mortar strength. At 7 days, the 2.5% CFA mix achieved 15.33 MPa, surpassing the control (13.52 MPa), indicating improved early-stage strength. However, increasing CFA to 5% and 7% led to lower strengths of 12.93 MPa and 10.47 MPa, respectively, aligning with findings from Amah et al. (2021) [10].

By 28 days, the 2.5% CFA sample maintained the highest strength at 23.87 MPa, exceeding the control (21.56 MPa). The 5% CFA mix remained structurally viable at 19.22 MPa, while 7% substitution significantly weakened the mortar (11.44 MPa). These results suggest that small CFA additions can enhance strength, but higher levels negatively impact cement hydration.

Overall, 2.5% CFA appears to be the optimal replacement level, improving both early and long-term strength while promoting sustainability. Higher percentages reduce performance, highlighting the need for balance in substitution levels.

4.1.3 Flexural Strength

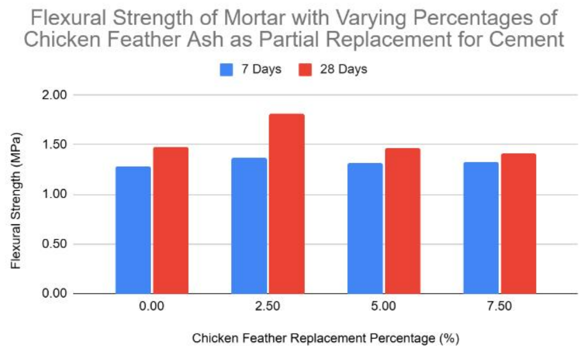


Fig. 3. Flexural Strength of Mortar

The flexural strength analysis showed that 2.5% CFA substitution yielded the best results, reaching 1.81 MPa at 28 days, outperforming the control mix (0% CFA) and other substitution levels. While the 5% CFA mix showed some improvement over time, it remained lower than the control, and the 7.5% substitution resulted in only a slight reduction in strength.

These findings align with Hafez et al. (2023) [11], who observed that beyond a certain CFA threshold, mechanical properties decline. The results suggest that lower CFA levels, particularly 2.5%, enhance flexural strength effectively, while higher percentages offer minimal benefits or lead to performance loss over time.

4.2 Concrete Mix with with Chicken Feather Ash as Partial Replacement for Cement and Coconut Shells as Substitute for Coarse Aggregates

4.2.1 Slump Test

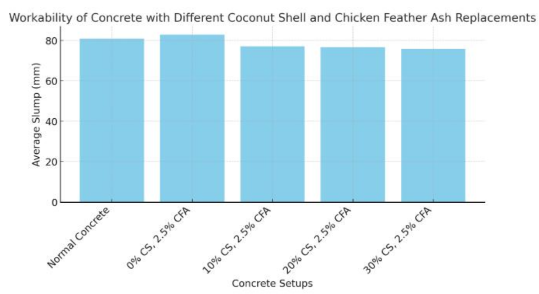


Fig. 4. Workability of Concrete

The slump test results demonstrate the impact of incorporating 2.5% chicken feather ash (CFA) as a partial cement replacement and varying percentages of coconut shells as coarse aggregate on concrete workability. The control mix, without any substitutions, achieved the highest slump value of 80.83 mm. When 2.5% CFA was introduced without coconut shells, the slump slightly increased to 82.91 mm, indicating improved workability, potentially due to the finer particle size or pozzolanic activity of CFA. However, with the addition of coconut shells at 10%, 20%, and 30%, a gradual decline in workability was observed, with slump values decreasing to 77.16 mm, 76.67 mm, and 75.79 mm, respectively. This reduction is attributed to the irregular shape and high porosity of coconut shells, which increase water absorption and reduce mix cohesiveness. Statistical analysis using one-way ANOVA revealed a significant difference in slump values across the five mixes ($F(4,35) = 23.97$, $p < 0.0001$). Post-hoc analysis via Tukey's Honest Significant Difference (HSD) test confirmed that the control mix significantly differed from all modified mixes, and the mix containing 30% coconut shells showed the most pronounced reduction in workability.

These findings suggest that while CFA enhances concrete fluidity, increasing coconut shell content diminishes workability. Nonetheless, the combination of CFA and coconut shells remains viable for sustainable concrete production, with acceptable workability levels for construction applications.

4.2.2 Compressive Strength

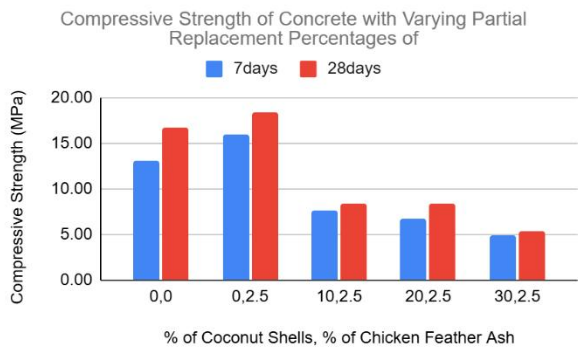


Fig. 5. Compressive Strength of Concrete

The compressive strength results across various curing periods and substitution levels of chicken feather ash (CFA) and coconut shells (CS) revealed clear performance trends. The mix incorporating 2.5% CFA and 0% CS achieved the highest compressive strengths, with 15.97 MPa at 7 days and 18.36 MPa at 28 days—exceeding the control mix (13.10 MPa at 7 days and 16.74 MPa at 28 days). However, increasing CS content to 10%, 20%, and 30% led to a progressive reduction in strength. At 7 days, compressive strengths declined to 8.35 MPa, 6.03 MPa, and 4.92 MPa, respectively. This trend continued at 28 days, with values of 7.66 MPa, 6.77 MPa, and 5.32 MPa. These findings indicate an inverse correlation between CS content and compressive strength, likely due to the weaker mechanical properties and porous nature of coconut shells.

A study by Boston-Osoteo et al. (2022) [12] examined the incorporation of rice husk ash (RHA) and coconut shell ash (CSA) as partial substitutes for cement in concrete. Their study revealed that a combination of 20% rice husk ash (RHA) and 5% coconut shell ash (CSA) resulted in the highest compressive strength of 2.72 MPa. This combination suggested an optimal range for the replacement of cement to maximize strength, and the study highlighted that exceeding a certain replacement threshold (30%) caused a decline in compressive strength. These findings mirrored what was observed in this study, where the use of chicken feather ash (CFA) and coconut shells as partial replacements for cement and coarse aggregates followed similar trends. The decline in compressive strength is consistent with their findings, where an increase in CSA content beyond the optimal level led to a decrease in compressive strength. In this study, the inverse relationship between CS substitution and compressive strength is evident, supporting the notion that excessive introduction of the agricultural waste material in the mix could be detrimental to concrete performance. Nonetheless, the results aligned with Boston-Osoteo et al. (2022) [12] in such a way that CFA enhances the compressive strength of concrete such that it is stronger than that of conventional concrete.

The results also aligned with Bhoj et al. (2023) [13], in which they reported up to 24% reduction in strength at 15% CS substitution, with further losses at higher levels. While moderate CS substitution may be acceptable, higher percentages significantly compromise performance. Statistical analysis using one-way ANOVA confirmed significant differences among the mixes ($F(4,35) = 30.38$, $p < 0.0001$). Post-hoc Tukey's HSD analysis showed that the 2.5% CFA (0% CS) mix significantly outperformed all CS-containing mixes, while differences among the 10%, 20%, and 30% CS groups were not statistically significant.
In summary, 2.5% CFA enhances compressive strength, but increasing CS content substantially diminishes it. These findings highlight the need for optimized substitution ratios to balance sustainability and structural integrity in concrete design.

4.2.3 Split Tensile Strength

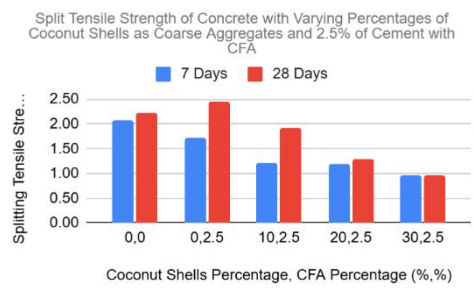
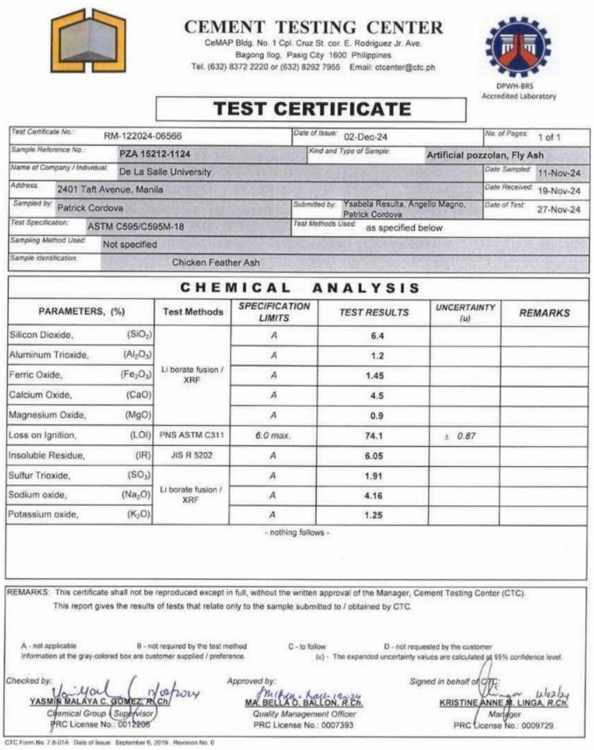


Fig. 6. Split-Tensile Strength of Concrete

The 7-day split tensile strength tests revealed that the mixture containing 0% coconut shell (CS) as coarse aggregate and 2.5% chicken feather ash (CFA) as a partial cement replacement achieved the highest average strength of 2.45 MPa among all samples. This result exceeded the average strength of the standard concrete mix by 0.21 MPa. Consistent with the observed compressive strength trends, the split tensile strength decreased with increasing CS content—recording values of 1.93 MPa, 1.29 MPa, and 0.97 MPa for 10%, 20%, and 30% CS replacements, respectively.

After 28 days of curing, the data continued to demonstrate a declining trend in split tensile strength with increasing CS content despite the inclusion of 2.5% CFA. The control mix recorded an average of 2.06 MPa, followed by values of 1.73 MPa, 1.21 MPa, 1.18 MPa, and 0.95 MPa for mixtures containing 0%, 10%, 20%, and 30% CS substitutions, respectively. These findings reinforce the conclusion that while 2.5% CFA may enhance tensile strength, higher levels of CS substitution negatively affect the mechanical performance of the concrete.

4.3 Chemical Analysis of Chicken Feather Ash



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TEST CERTIFICATE

Test Certificate No.: RM-122024-06566	Date of Issue: 02-Dec-24		No. of Pages: 1 of 1
Sample Reference No.: PZA 15212-1124	Kind and Type of Sample: Artificial pozzolan, Fly Ash		
Name of Company / Individual: De La Salle University			Date Sampled: 11-Nov-24
Address: 2401 Taft Avenue, Manila			Date Received: 19-Nov-24
Sampled by: Patrick Cordova	Submitted by: Ysabela Resulta, Angello Magno, Patrick Cordova		Date of Test: 27-Nov-24
Test Specification: ASTM C595/C595M-18	Test Methods Used: as specified below		
Sampling Method Used: Not specified			
Sample identification: Chicken Feather Ash			

CHEMICAL ANALYSIS

PARAMETERS, (%)		Test Methods	SPECIFICATION LIMITS	TEST RESULTS	UNCERTAINTY (u)	REMARKS
Silicon Dioxide,	(SiO_2)	Li borate fusion / XRF	A	6.4		
Aluminum Trioxide,	(Al_2O_3)		A	1.2		
Ferric Oxide,	(Fe_2O_3)		A	1.45		
Calcium Oxide,	(CaO)		A	4.5		
Magnesium Oxide,	(MgO)		A	0.9		
Loss on Ignition,	(LOI)	PNS ASTM C311	6.0 max.	74.1	± 0.87	
Insoluble Residue,	(IR)	JIS R 5202	A	6.05		
Sulfur Trioxide,	(SO_3)	Li borate fusion / XRF	A	1.91		
Sodium oxide,	(Na_2O)		A	4.16		
Potassium oxide,	(K_2O)		A	1.25		

- nothing follows -

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A - not applicable B - not required by the test method C - to follow D - not requested by the customer
Information at the gray-colored box are customer supplied / preference. (u) - The expanded uncertainty values are calculated at 95% confidence level.

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Approved by: MA. BELLA O. BALLON, R.Ch. Quality Management Officer PRC License No.: 0007393

Signed in behalf of CTC: KRISTINE ANNE M. LINGA, R.Ch. Manager PRC License No.: 0009729

CTC Form No. 7.8-01A Date of Issue: September 6, 2019 Revision No. 0

Fig. 7. Chemical Analysis of Chicken Feather Ash

The chemical composition of chicken feather ash (CFA) was analyzed to assess its potential impact as a partial cement replacement in concrete. The results showed that CFA contains 6.4% Silicon Dioxide (SiO_2), 1.2% Aluminum Trioxide (Al_2O_3), and 1.45% Ferric Oxide (Fe_2O_3), which can react with calcium hydroxide during hydration, potentially enhancing strength and density [14]. Despite that the percentages of these compounds are lower than fly ash or silica fume, CFA may still improve concrete performance in small percentages.

Additionally, CFA contains Calcium Oxide (CaO) and Magnesium Oxide (MgO), which may aid in early strength development and durability. In a study by Mahdi et al. (2020) [15] they stated that adding CaO to concrete mixtures significantly increases compressive strength over time. Moreover, the presence of MgO in CFA offers additional benefits. Under certain conditions, MgO can reduce thermal shrinkage, lower concrete costs by minimizing expensive cooling measures, and accelerate construction speed [16]. However, a high Loss on Ignition (LOI) value of 74.1% indicates a significant organic content, whose effects on curing and strength require further study. The insoluble residue of 6.05% suggests non-reactive materials that might still help fill voids in the mix.

Using 2.5% CFA as a cement substitute could promote pozzolanic reactions, reducing large pores and increasing density. While further testing is needed, these findings suggest CFA has potential as a supplementary cementitious material.

5. CONCLUSIONS

This study examined the impact of partially substituting cement with chicken feather ash (CFA) and replacing coarse aggregates with coconut shells in concrete mixtures. The objectives included identifying the optimal CFA percentage for maximizing workability, compressive strength, and flexural strength of CFA-enhanced mortar. In addition, the optimal coconut shell percentage when used with CFA, wherein the workability, compressive strength, and split-tensile strength incorporating both materials.

After testing in accordance with ASTM standards, the results indicated that a 2.5% CFA replacement yielded the highest compressive strength, aligning with National Structural Code of the Philippines (NSCP) standards and proving suitable for structural use. This mix also demonstrated superior workability, as shown by elevated slump values that suggest enhanced fluidity and ease of application.

In contrast, increasing the proportion of coconut shells led to a noticeable reduction in compressive strength, attributed to their porous texture and irregular shape, which compromise the bond between the aggregates and cement. Therefore, the combination of 2.5% CFA without coconut shell substitution was identified as the most effective for achieving both strength and workability. As for split-tensile strength, mixes containing both CFA and coconut shells underperformed compared to standard concrete, indicating that while CFA enhances certain mechanical properties, coconut shells may not be suitable for applications where tensile strength is critical.

In conclusion, the findings of this study support the use of 2.5% CFA as a partial cement replacement in concrete without the inclusion of coconut shells. This combination provides an optimal balance of enhanced compressive strength, improved workability, and material sustainability. Furthermore, the use of CFA contributes to waste valorization and carbon footprint reduction, offering a promising approach for environmentally responsible construction practices.

6. RECOMMENDATIONS

The study recommends utilizing concrete with 2.5% chicken feather ash (CFA) and no coarse aggregate substitution, as it consistently achieved superior compressive strength and workability compared to conventional concrete. This mix meets NSCP standards, making it viable for typical residential and commercial applications. Incorporating CFA at this level offers environmental benefits by reducing cement use and repurposing waste materials, thereby lowering CO_2 emissions.

Given its enhanced workability, the 2.5% CFA mix is well-suited for general structural applications such as housing and walkways, as well as architectural elements requiring better flow and finish. Future research should evaluate the long-term durability of CFA-based concrete under varied environmental conditions and explore synergies with other sustainable materials. Additionally, industry adaptation may require training programs and the development of quality standards to ensure consistent CFA performance in field applications

7. REFERNECES

[1] N. Mohamad, K. Muthusamy, R. Embong, A. Kusbiantoro, M.H. Hashim, Environmental impact of cement production and solutions: A review, Mater. Today Proc. 48 (2022) 741–746. https://doi.org/10.1016/j.matpr.2021.02.212

[2] C.O. Nwankwo, G. Bamigboye, I.E. Davies, T.A. Michaels, High volume Portland cement replacement: A review, Constr. Build. Mater. 260 (2020) 120445. https://doi.org/10.1016/j.conbuildmat.2020.120445

[3] Y. Su, Y.L. Yao, Y. Wang, X. Zhao, L. Li, J. Zhang, Modification of recycled concrete aggregate and its use in concrete: An overview of research progress, Mater. 16(22) (2023) 7144. https://doi.org/10.3390/ma16227144

[4] V.D. Katare, M.V. Madurwar, Application of solid wastes for the production of sustainable concrete, Lect. Notes Civ. Eng. (2018) 108–121. https://doi.org/10.1007/978-3-319-64349-6_10

[5] M.N. Acda, Waste chicken feather as reinforcement in cement-bonded composites, Philipp. J. Sci. 139(2) (2010). http://philjournalsci.dost.gov.ph/vol139no2/pdfs/Waste%20chicken%20feather.pdf

[6] G.P. Manginsay, R.R. Cabahug, Chicken feathers as substitute for fine aggregates in concrete, Mindanao J. Sci. Technol. 13(1) (2015) 1. https://ejournals.ph/article.php?id=12576

[7] N.N.V.S. Jalipa, N.R.S.Y. Lim, N.R.C.F. Matias, N.N.B.F. Villademosa, N.D.N.R. Valerio, N.M.K.M. Daly, N.K.J.T. Elevado, Investigating the mechanical performance of concrete by incorporating poultry slaughterhouse wastewater treatment plant sludge as a partial cement replacement, Proc. Int. Exch. Innov. Conf. Eng. Sci. (IEICES) 10 (2024) 964–970. https://doi.org/10.5109/7323376

[8] G.Y. Obeng, D.Y. Amoah, R. Opoku, C.K.K. Sekyere, E.A. Adjei, E. Mensah, Coconut wastes as bioresource for sustainable energy: Quantifying wastes, calorific values and emissions in Ghana, Energies 13(9) (2020) 2178. https://doi.org/10.3390/en13092178

[9] A. Derrick, Analysis of emissions and energy content of coconut husk, Kwame Nkrumah Univ. Sci. Technol. (2016).

[10] V.E. Amah, E. Ugwoha, J. Macaulay, Chicken feather ash (CFA) as a partial replacement of cement in concrete, J. Eng. Res. Rep. (2021) 130–140. https://doi.org/10.9734/jerr/2021/v20i117256

[11] R.D.A. Hafez, M. Hadzima-Nyarko, S.M. Ahmed, B.A. Tayeh, Recycled chicken feather sand as a partial replacement for natural sand for producing eco-friendly mortar, Buildings 13(2) (2023) 421. https://doi.org/10.3390/buildings13020421

[12] N.M.R. Boston-Osoteo, N.A.J.B. Pontillo, N.A.G. Apdohan, Utilization and evaluation of rice husk ash and coconut shell ash as partial cement replacement for concrete hollow blocks production, Proc. Int. Exch. Innov. Conf. Eng. Sci. (IEICES) 8 (2022) 360–365. https://doi.org/10.5109/5909117

[13] S. Bhoj, A. Manoj, S. Bhaskar, Usage potential and benefits of processed coconut shells in concrete as coarse aggregates, Mater. Today Proc. (2023). https://doi.org/10.1016/j.matpr.2023.03.529

[14] C. Zhuang, Y. Chen, The effect of nano-SiO_2 on concrete properties: A review, Nanotechnol. Rev. 8(1) (2019) 562–572. https://doi.org/10.1515/ntrev-2019-0050

[15] Z.H. Mahdi, W.A. Abbas, F.K. Abdulhussein, M.R. Abdulghani, M.Q. Hasan, Compressive strength and shrinkage of concrete containing calcium oxide (CaO) powder, IOP Conf. Ser. Mater. Sci. Eng. 881(1) (2020) 012165. https://doi.org/10.1088/1757-899X/881/1/012165

[16] J. Nobre, H. Ahmed, M. Bravo, L. Evangelista, J. De Brito, Magnesia (MgO) production and characterization, and its influence on the performance of cementitious materials: A review, Mater. 13(21) (2020) 4752. https://doi.org/10.3390/ma13214752