International Journal of Constructive Research in Civil Engineering (ijcrce)
Volume 9, Issue 1, 2025, PP 24-29
ISSN 2454-8693 (Online)
DOI: https:// doi.org/10.20431/2454-8693.0901003
www.arcjournals.org

Utilizing Carbonized Rice (*Oryza sativa*) Hull Ash from Pilmico Waste as an Admixture for Concrete Posts

Dara Lianne S. Chamen[1]*, Princess Emerald A. Panchacala[1], Earl Andrei Q. Estacio, Carl Antoine T. Dumas, Erich Althea E. Pepito[1], and Ian Jay P. Saldo[2]

[1]*Integrated Basic Education, San Isidro College, Malabalay City, Bukidnon, Philippines*
[2]*School of Education, San Isidro College Integrated Basic Education, Malabalay City, Bukidnon, Philippines*

Corresponding Author:** ***Dara Lianne S. Chamen, *Integrated Basic Education, San Isidro College, Malabalay City, Bukidnon, Philippines.*

Abstract: *Concrete, essential for construction due to its strength and adaptability, contributes significantly to carbon dioxide emissions, primarily from the production of Portland Cement, which consumes natural resources and energy. This study explored the potential of using carbonized rice hull ash (CRHA), a byproduct from Pilmico, an agricultural company in Iligan City, as an eco-friendly admixture in concrete. The study used an experimental design to create concrete posts with varying CRHA-to-cement ratios. A 1:7 (cement:sand) mixture, measured by volume, served as the control, comprising seven buckets of sand, one bucket of Portland cement, and half a bucket of water. Treatments included CRHA additions of ¼ bucket (T1), ½ bucket (T2), and ¾ bucket (T3). Compressive strength tests, compared with control and commercial posts, were conducted at Allied Material Testing Laboratories after 20 and 30 days of curing to assess durability and strength. The high silica content of Pimlico's CRHA (89.61%) enhances pozzolanic reactivity but reduces compressive strength as its proportion increases. Treatments with 25%, 50%, and 75% CRHA substitution showed decreasing strength, with T1 (979-1112 Psi) outperforming T2 and T3. The control mixture (2100-3200 Psi) remained superior. Higher CRHA content caused structural damage, darker coloration, and workability issues due to lack of proper hydration of posts. Variations in CRHA quality and alkali-silica reactions also compromised durability. The study concludes that while CRHA enhances environmental sustainability, higher concentrations may compromise compressive strength and alter general appearance, necessitating careful use in structural applications. Further research is needed to optimize CRHA ratios and evaluate additional properties to balance environmental benefits with mechanical performance.*.

Keywords: *Carbonized Rice Hull Ash (CRHA), Compressive Strength, Concrete, Concrete posts, General Appearance Test, Pilmico, Portland Cement, Waste Management*

1. Introduction

Concrete is renowned in construction for its strength, resilience, and adaptability [1]. Nonetheless, there has been increasing pressure on the construction sector in recent years to implement sustainable methods and lessen its environmental impact. A study indicated that the production of concrete, specifically the manufacturing of Portland Cement, significantly emits greenhouse gases, which contribute to global carbon dioxide emissions resulting in detrimental environmental effects [2]. This is primarily due to the substantial consumption of limestone and other raw natural materials essential for cement production, which involves energy-intensive processes and chemical reactions [3]. Since concrete is extensively used in construction worldwide, its production contributes significantly to the global carbon footprint, thereby worsening its environmental impact [4]. As a result, researchers and industry professionals are developing sustainable and alternative methods to create environmentally friendly concrete formulations [5].

Studies have shown that the use of carbonized rice hull ashes (CRHA) as an admixture has numerous benefits on cost reduction, utilization of agricultural waste for environmental sustainability, enhancing concrete properties, and promoting local sourcing of materials [6,7]. Substituting a portion of Portland cement with carbonized rice hull ashes (CRHA), can reduce material expenses for construction projects while mitigating the environmental impact of concrete production [8]. As a byproduct of rice hulls, carbonized rice hull ashes divert potential pollutants and chemicals from landfills and contribute to a circular economy by repurposing agricultural wastes [9]. Moreover, cement manufacturing is known for its high energy demand, and incorporating carbonized rice husk ash (CRHA) into concrete as a partial substitute for Portland cement offers a promising strategy to reduce energy consumption during concrete production [10]. Additionally, CRHA enhances concrete mixes' strength, durability, and workability, potentially improving long-term performance [11]. Furthermore, the study states that local sourcing of CRHA supports regional economies and reduces transportation-related carbon emissions., and social acceptability [1], [2].

Combustion of rice hulls during rice production yields carbonized rice hull ash (CRHA), comprising approximately 18% of the husk [12,13]. CRHA retains silica from the husk while eliminating lignin and cellulose, producing a predominantly silica-based residue [14]. Typically, CRHA exhibits a fine particle size of 5 to 10 µm and a porous structure, providing a specific surface area of up to 100 m^2/g, which enhances its reactivity and adsorption capabilities [15]. With a silica content ranging from 90% to 96% in its amorphous form, carbonized rice hull ash (CRHA) exhibits excellent pozzolanic properties. This allows CRHA to react with calcium hydroxide in the presence of water, forming cementitious compounds and making it a valuable supplementary material in concrete and other cement-based applications [16].

Pilmico, one of the top agricultural companies producing animal feeds in Iligan City, Lanao del Norte, Philippines, generates a sizable amount of carbonized rice hull ashes as waste. In the process, it uses rice hulls as biofuel. The ashes can be produced in tons per day and become hazardous as they pile up in their waste yard. Hence, waste disposal is their number one problem. This premise leads the researchers to explore and evaluate the possibility of using this waste as an admixture for concrete posts. It further aims to contribute valuable insights into sustainable construction and waste management practices within the agricultural sector.

2. METHODOLOGY

In this chapter, the research methodologies used to carry out the study are clearly described. This section explains the methodology the team of investigators used to gather, present, and analyze the necessary data and information to successfully respond to study goals and inquiries. This section provides rationales and reasons for the chosen research design, research instruments, data sources, data collection methodologies, data presentation approaches, and analytical techniques used in the study.

2.1. Research Design

An experimental research design was employed in this study. The concrete posts were created with varying measurements of CRHA to assess which of the samples produced the best results. These differences among treatments were presented in tables, describing the characteristics of each sample by its size, shape, and color. Furthermore, the researchers compared the effectiveness of each concrete post by analyzing the compressive strength results from Allied Material Testing Laboratories (AMTL), a Department of Public Works and Highways (DPWH) facility. Lastly, the data results were presented through a descriptive and experimental summary.

2.2. Entry Protocol

In preparation for the conduct of this study, the researchers wrote a letter to secure proper consent and permission requesting the following in charge: the principal of San Isidro Integrated Education, the vice president, the science research adviser, and the parents of the researchers involved in conducting this study. Secondly, the researchers prepared another separate letter, reaching out to an expert, a former researcher from Dole Philippines, to aid with guidance and suggestions on the study. The researchers offered compensation as a sign of respect and gratitude for the expert's time and expertise. Furthermore, a formal letter was made and addressed to Pilmico by the researchers to gain access to the test results and findings of the properties found in the corporation's carbonated rice hull ash waste. The researchers explicitly stated in the letter that the intention of the researchers in this study is to use the information and data from the test results of the carbonated rice hull ashes solely for research purposes and this study. Lastly, the researchers inquired ahead of time at the Allied Material Testing Laboratories-Malaybalay Branch to test the compressive strength of the posts made of carbonated rice hull ash and concrete cement and the data results.

2.3. Locale of the Study

The study was conducted in CJB Lumber and Construction Supply, Barangay 9 Terminal, Malaybalay City, Bukidnon, Philippines. This location was chosen for its accessibility to construction supplies like cement and its suitability for experimenting. The Ordinary Portland Cement was provided at the same place where the study was conducted, ensuring better consistency and convenience in material procurement. The carbonated rice hull ash was sourced from Pilmico and brought to the mixing site in a sack. Additional materials used in the study, such as gloves, shovels, and buckets for measuring the cement and ash, were purchased from Wilcon Depot, Malaybalay City, Bukidnon. Nine molds for the posts were made in advance for the concrete-rice hull mixture. The finished posts were brought to Allied Material Testing Laboratories-Malaybalay Branch for further testing, ensuring the accuracy of the results through professional testing facilities.

2.4. Collection and Preparation of Samples

The following materials were used: Ordinary Portland Cement (OPC), mixed sand, and carbonized rice hull ashes. The mixed sand and Ordinary Portland Cement were acquired from CJB Lumber and Construction Supply. The carbonized rice hull ashes were acquired from Pilmico, Iligan Branch. The cylindrical post molds were fabricated beforehand for the researchers. The molds were made from metal pipes that were cut in half with hinges welded to the pipes for easier removal. Motor oil was applied to the inside of the molds to prevent sticking. The apparatus used to test the durability and effectiveness of the concrete posts is a compression molding hydraulic press.

2.5. Preparation of Carbonized Rice Hull Ashes

In this study, the CRHA was sourced from Pilmico's Iligan Branch by Pitac-MPC Main branch, a multipurpose cooperative primarily focused on financing agricultural crop production. Pitac-MPC had established a memorandum agreement with Pilmico, Iligan branch, one of the Philippines' largest Agribusiness and Food & Nutrition companies of the Aboitiz Group, to collect the biomass waste of Pilmico, which is the carbonated rice hull ash and was later given to the clients of Pitac-MPC, who are farmers of rice and corn fields. The researchers sought permission from Pitac-MPC to acquire samples for this study. The researchers obtained sufficient CRHA samples for this study and were provided with two sacks of CRHA, each weighing around 30 kilograms.

2.6. Design of Treatments (Concrete Post Mixtures)

In this study, the CRHA was sourced from Pilmico's Iligan Branch by Pitac-MPC Main branch, a multipurpose cooperative primarily focused on financing agricultural crop production. Pitac-MPC had established a memorandum agreement with Pilmico, Iligan branch, one of the Philippines' largest Agribusiness and Food & Nutrition companies of the Aboitiz Group, to collect the biomass waste of Pilmico, which is the carbonated rice hull ash and was later given to the clients of Pitac-MPC, who are farmers of rice and corn fields. The researchers sought permission from Pitac-MPC to acquire samples for this study. The researchers obtained sufficient CRHA samples for this study and were provided with two sacks of CRHA, each weighing around 30 kilograms.

2.7. Test Analysis

Two (2) types of testing were conducted. These were the compressive strength, size, shape, and color (general appearance) tests. Furthermore, the concrete posts were sent to Allied Materials Testing Laboratories – Malaybalay Branch for the compressive strength test. The size, shape, and color tests were conducted manually at CJB Lumber and Construction Supply. Through these, the researchers identified the implications of incorporating CRHA in their concrete posts.

2.8. Compressive Strength Test and General Appearance Test (Size, Shape, and Color Test)

Two (2) types of testing were conducted. These were the compressive strength, size, shape, and color (general appearance) tests. Furthermore, the concrete posts were sent to Allied Materials Testing Laboratories – Malaybalay Branch for the compressive strength test. The size, shape, and color tests were conducted manually at CJB Lumber and Construction Supply. Through these, the researchers identified the implications of incorporating CRHA in their concrete posts.

2.9. Data Gathering Procedure

The concrete posts were compared to the controlled variable's commercial posts. Visual observation was utilized after creating the 3 concrete posts to gather information and insights about the difference in size, shape, and color with varying concentrations of CRHA. Moreover, by testing the compressive strength of each post in AMTL, the researchers obtained official test results. Details about the critical properties of CRHA waste from Pilmico were obtained by sending letters to one of the staff through connections. This, in turn, gave them access to a comprehensive list of parameters that demonstrated its significance in the properties of the 3 CRHA concrete posts

3. Results and Discussion

The use of CRHA in construction has been studied well and is being applied anywhere commercially. This led the researchers to evaluate the waste product of Pilmico, an animal feed industry that is using rice hulls as biofuel. Due to its tons of waste every day, it has become their number one problem. This study intends to determine its properties, effects, and significant differences between the commercial concrete posts and CRHA posts depending on each curing days (20-30 days curing period) and will be investigated in terms of different tests provided. This research will also help with environmental issues by providing valuable and trusted information on the potential use of CRHA as an admixture for concrete posts, which could further be a viable alternative for those in the construction industry. The properties present in the CRHA waste from Pilmico were presented as follows

Table1: *Results of the Analysis of CRHA sample from Pilmico Wastes.*

Parameter	Results
Silica (%)	89.61
Calcium	0.25
Phosphorus	0.25
Magnesium (mg/kg)	1,065.09
Zinc (mg/kg)	40.71
Potassium (mg/kg)	7940.88

Table2: *Comparison at 20 and 30 days curing on the compressive strength of the different treatments.*

Treatment	Age (Days)	Compressive Strength	Condition of Samples	Color	Type of Fracture
T1	20 30	979 1112	Dry on Receipt	Light grey, with smudges of dark grey, lighter than T3	Type 3
T2	20 30	690 1091	Dry on Receipt	Uniformly light grey exterior and darker interior than T1	Type 3
T3	20 30	242 469	Dry on Receipt	Darkest interior compared to T1 and T3	Type 3
Control	20 30	2100 – 2300 2800 - 3200	Dry on Receipt	Light grey	Type 2

Note: Columnar vertical cracking through both ends, no well-formed cones (Type 3).

The Carbonized Rice Hulls Ash (CRHA) from Pilmico has a high silica content of 89.61%, which is pivotal due to its pozzolanic reactivity and is advantageous in concrete construction because of its high pozzolanic reactivity and silica content. Furthermore, this waste material contains important elements needed for concrete such as the presence of calcium and iron. Furthermore, CRHA contains other elements such as calcium (0.25%), phosphorus (0.20%), magnesium (1,065.09 mg/kg), iron (535.63 mg/kg), zinc (40.71 mg/kg), and potassium (7,940.88 mg/kg), which play supportive roles in concrete chemistry. However, increased proportions of CRHA leads to the compromised compressive strength as shown in various treatments with Treatment 1 (T1), composed of 25% CRHA and 75% Portland cement, showed the highest compressive strength, achieving 979 Psi at 20 days and increasing to 1112 Psi at 30 days. Treatment 2 (T2), with a 50:50 CRHA to cement ratio, with 690 Psi and 1091 Psi at the respective intervals. Treatment 3 (T3), with 75% CRHA, had the lowest strength, registering 242 Psi at 20 days and 469 Psi at 30 days. Furthermore, the control sample that was sourced from Allied Material Testing Laboratories, made entirely of Portland cement, recorded accordingly between the estimate of 2100 - 2300 Psi in 20 days which increased to an estimate of 2800 - 3200 Psi at 30 days.

Higher CRHA content resulted in more extensive damage and darker coloration in the samples. Although the utilization of CRHA can reduce environmental impact, managing its mechanical properties is crucial for successful application in concrete. Variability in CRHA properties, depending on source and processing, can lead to inconsistent concrete performance, highlighting the need for quality control. Additionally, the potential for alkali-silica reaction (ASR) raises concerns about the durability of concrete with CRHA. Further research is needed to optimize CRHA content in concrete mixtures to balance sustainability and performance.

4. Conclusion

All treatments were significantly below the compressive strength of the control mixture. These results indicate that while a lower ratio of CRHA can slightly enhance strength over time, higher ratios considerably weaken the concrete's compressive strength. Each concrete post initially had a uniform cylindrical shape, measuring 12 inches in height and 5 cm in width. Post-testing, Treatment 1 (T1) retained its shape with minor internal stress, evidenced by light side cracks and noticeable chipping and cement loss, particularly at the rim. Treatment 2 (T2) exhibited significant structural damage, including columnar vertical cracking (Type 3) and a side fracture at the top, indicating severe stress concentration. Treatment 3 (T3) suffered the most extensive damage, losing nearly half its shape and breaking into three vertical parts due to severe columnar vertical cracking.

Color-wise, T1's exterior was light grey with dark grey smudges, indicating slight discoloration. T2 had a uniformly light grey exterior but a darker interior, suggesting higher internal carbon content. T3's exterior was slightly darker grey with prominent discoloration and extensive dark smudges, and its interior was the darkest among the treatments, reflecting its high CRHA content. The control post, devoid of CRHA, maintained a uniform light grey color with no discoloration, representing the standard concrete appearance without CRHA.

Moreover, the data depicted that incorporating CRHA from Pilmico into concrete weakened the compressive strength of the posts compared to commercial standards, showing posts with this material having compressive strengths between 242 to 1112 Psi, which is significantly lower than the latter. Higher proportions of CRHA result in further reduced strength, with Treatment 3 (75% CRHA) showing the weakest performance. Despite potential environmental benefits and improved workability, CRHA's impact on compressive strength suggests that its use in concrete mixtures needs careful optimization to meet structural standards.

Factors such as the ratio of CRHA to cement, water content, and variations in CRHA properties due to sourcing and processing methods contributed to inconsistencies in concrete performance. Moreover, the alkali-silica reaction (ASR) between silica in CRHA and alkalis in concrete mixtures can compromise durability, leading to cracking and reduced service life of concrete structures. While CRHA can improve workability, higher substitution levels often result in decreased compressive strength and workability issues due to increased water absorption. These findings highlight the difficulties in effectively using CRHA in concrete production, underlining the importance of rigorous quality control processes and precise adjustment of mix ratios to reduce potential negative impacts on concrete properties and environmental sustainability

Exploration of different ratios of cement and CRHA is necessary to optimize concrete mixtures. To add, further trials should also focus and several samples should be made on determining the ideal proportions of water and sand in CRHA-infused concrete mixtures. Moreover, more tests such as moisture content, flexural strength, fire retardant capability, and compaction factor test to provide more satisfactory and dependable results. Consideration should be given to the fact that CRHA is a waste material, prompting the need for sustainable utilization through innovative concrete formulations. Manufacturing and disposal of this can have adverse environmental impacts, including air and water pollution, soil contamination, and ecosystem.

Furthermore, the research being in an exploratory phase offers opportunities for young scientists to experiment with various mixtures and admixtures for concrete posts. disruption, underscoring the importance of responsible usage and waste management practices.

References

[1] Gagg, C. R. (2014). Cement and concrete as an engineering material: An historic appraisal and case study analysis. Engineering Failure Analysis, 40, 114–140. https://doi.org/10.1016/j.engfailanal.2014.02.004

[2] Moungam, E., Njopwouo, D., Njopwouo, R., & Ndjaka, J. (2017). Utilization of rice husk ash and waste

glass powder in concrete production: A review. Materials Today: Proceedings, 4(2), 1293–1302. https://doi.org/10.1016/j.matpr.2017.01.174

[3] Tang, W. (2019). Environmental impact of cement production: Detail of the life cycle assessment (LCA). Journal of Cleaner Production, 237, 117803. https://doi.org/10.1016/j.jclepro.2019.117803

[4] Cembureau. (2021). The role of cement in the 2050 low carbon economy. Retrieved from https://cembureau.eu/policy-focus/the-role-of-cement-in-the-2050-low-carbon-economy/

[5] Kumar, S., Kumar, R., & Siddique, R. (2020). Sustainable construction materials: Rice husk ash. In M. N. Soutsos, T. H. Pandey, & J. K. Agarwal (Eds.), Sustainable Construction Materials (pp. 241-265). Woodhead Publishing.

[6] Akinshipe, T. B., & Ogubiyi, D. O. (2020). Utilization of agricultural waste in concrete production: A review. Journal of Cleaner Production, 258, 120785. https://doi.org/10.1016/j.jclepro.2020.120785

[7] Dassanayake, D. K., & Jayawardena, S. D. (2018). Benefits of using agricultural waste in sustainable concrete production. Construction and Building Materials, 187, 420-429. https://doi.org/10.1016/j.conbuildmat.2018.07.123

[8] Tay, Y. W. D. (2020). Sustainable Use of Waste Materials in Construction: Carbonized Rice Hull Ash. Journal of Sustainable Construction Materials and Technologies, 1(1), 25-32. https://doi.org/10.1016/jsucmt.2020.100002

[9] Mansur, M. A., Azad, A. K., Islam, M. R., & Hossain, M. M. (2013). Properties of concrete containing rice husk ash. Journal of Materials in Civil Engineering, 25(9), 1249–1254. https://doi.org/10.1061/(ASCE)MT.1943-5533.0000654

[10] Cachim, P., & Said, A. M. (2018). Carbonized rice husk ash (CRHA) as partial cement replacement in construction materials: A review. Construction and Building Materials, 173, 303-317. https://doi.org/10.1016/j.conbuildmat.2018.03.238

[11] Siddique, R. (2013). Waste materials and by-products in concrete. Springer Science & Business Media. https://doi.org/10.1007/978-3-642-36721-2

[12] Maheswaran, A. S. M., Narayanan, P., & Gopinath, R. (2016). Utilization of Rice Husk Ash. In P. Pacheco-Torgal, J. Labrincha, C. Leonelli, A. Palomo, & P. Chindaprasirt (Eds.), Handbook of Low Carbon Concrete (pp. xxx-xxx). Woodhead Publishing. https://doi.org/10.1016/B978-0-12-805540-3.00004-1

[13] Mosaberpanah, E. (2020). Rice Husk Ash (RHA) as a Waste Material in Cement-Based Composite. Journal of Cleaner Production, 260, 120840. https://doi.org/10.1016/j.jclepro.2020.120840

[14] Saikia, N. (2017). Silica extraction from rice husk ash and its application in cementitious materials. Materials Science and Engineering: B, 176(20), 1733-1747. https://doi.org/10.1016/j.mseb.2017.10.001

[15] Khan, A. (2020). Rice husk ash: Properties and applications. Journal of Sustainable Materials, 8(2), 75-82. https://doi.org/10.2166/jsm.2020.008

[16] Ahmed, I. (2021). Utilization of Rice Husk Ash in Concrete as Cementitious Material. Journal of Materials Science Research and Reviews, 2(1), 1-10. https://doi.org/10.9734/JMSRR/2021/v2i130142

[17] Ali, M. (2019). Cement Hollow Blocks (CHB) and Cement Grills, (n.d) https://uomustansiriyah.edu.iq/media/lectures/5/5_2019_12_14!10_07_10_PM.pdf

Citation: *Dara Lianne S. Chamen., et.,al (2025). "Utilizing Carbonized Rice (Oryza sativa) Hull Ash from Pilmico Waste as an Admixture for Concrete Posts ". International Journal of Constructive Research in Civil Engineering (IJCRCE), vol. 9, no.1, pp.24-29, 2025. Available: DOI: https://doi.org/10.20431/2454-8693.0901003*