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Impact of rice husk ash on compressed cement-lateritic brick durability and microstructural characteristics

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Abstract

One of the potential ways to lower building costs and improve the quality of the environment in both urban and rural regions is to use local resources as a substitute for cement in building construction. The purpose of this study was to determine how Rice Husk Ash (RHA) affected the morphology and durability of cement-lateritic bricks. Analytical techniques were utilized in the lab to ascertain the RHA's chemical make-up. Compressed Earth Bricks (CEB) were created by employing water content of 20 to 25 percent and replacing 0 to 5 percent of the cement with 0 to 5 percent of RHA. Response Surface Methodology (RSM) of Design Expert software was used to create seventeen (17) variables for the CEB manufacture.The created CEBs underwent compressive strength and microstructural studies in the lab after being cured for 28, 56, and 108 days. According to the results, RHA is a powerful pozzolan with a high SiO_2 concentration that might potentially replace non-renewable silica as one of the primary cement sources of oxide that pozzolans react with. Most samples exhibit an increase in compressive strength with longer curing times and have a minimum strength of 1.65 N/mm^2 or higher.The microstructural study of the pozzolan revealed that it contains tiny particles. Consequently, as the curing age increased, the porosities decreased and the compressive strength of the stabilized bricks improved. In conclusion, the finest CEBs for building construction are those produced with 1.25 percent RHA and 23.75 percent water content.

Keywords: Compressive strength; Compressed earth brick; Durability; Microstructure; Morphology; Pozzolan

1. Introduction

One of a person's basic needs is a place to live. Everyone requires a place to call home, or shelter, in order to get the rest they need, feel at ease, and lead a comfortable existence. Home is when a house is filled with a variety of family members, and it is where all of them remain connected over the course of their lives rather than being dispersed in other locations. Therefore, a home is a place where we can stay connected to our families on a daily basis and where other families may gather together to share special moments. A house is also a place where several individuals share a living quarters and are referred to as a single family. Every person deserves a cozy place to live, and it is the responsibility of both private and public housing authorities to provide that, yet underdeveloped and emerging nations like Nigeria continue to struggle with the affordability and availability of decent housing [1].

Population growth leads to a rise in housing demand, which is then linked to the high cost of construction supplies. This demand has an impact on the overall cost of construction through other elements including the cost of building materials, such as walling units, which are entirely dependent on the excessive use of cement. Because of this, producing walling units is costly for the majority of people, especially those with very low incomes [2].Cement manufacture is costly, uses a lot of energy, depletes natural resources, and emits a lot of CO_2. According to reports, one ton of cement produces roughly one ton of CO_2 both directly and indirectly [3]. One recognized greenhouse gas, CO_2, is responsible for

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the greenhouse effect and global warming. Alternative materials are required since cement is expensive and has negative natural and environmental repercussions [2].

In many nations, it is acknowledged that providing a high standard of housing is a crucial part of ensuring the wellbeing of the populace. This is why natural resource-based building materials are frequently employed. Many sections of the world currently use supplemental cementitous materials that have successfully met the majority of the demands for lasting bricks and blended cement [4]. Pozzolan, an additional cementitious material, can be produced from agricultural and industrial waste, including sugarcane ash, wheat straw, rice husk, sawdust, and hazelnut shell ash, which can be used to partially replace cement. As their disposal is a significant issue, these wastes cause annoyance and contamination in the environment.

As a result, the potential use of those wastes as additives in the production of bricks will lessen or eliminate the environmental risks brought on by such waste and also make owning a home simple and cost-effective. In order to produce earth bricks, this study investigated the use of rice husk ash (RHA) as a partial replacement for cement. It looked into how durability and morphological traits of cement-lateritic bricks were affected by rice husk ash (RHA).

2. Material and methods

2.1. Materials

Lateritic soil, cement, RHA, and water are the components employed.

2.1.1. Lateritic soil

Lateritic soil is a naturally occurring aggregate utilized in civil engineering projects. The lateritic soil was acquired in its disturbed state from a borrow hole located beside CBN, new Iyin Road in Ado-Ekiti at a depth of 0.75 to 1.2 meters. To preserve its natural moisture content, the soil sample that was taken was placed in a polythene bag. To ensure that all moisture was removed before mixing, it was air dried.'

2.1.2. Cement

As a stabilizer, Portland Limestone Cement CEM II, BUA cement of grade 42.5N was utilized. To keep the cement from absorbing moisture, it was kept in an airtight drum.

2.1.3. Rice husk ash (RHA)

RHA was employed in the combinations as a full or partial replacement for cement. Igbemo-Ekiti is where the rice husks came from. The samples were gathered in sack bags, turned into ash in a metal drum by open burning, cooled, and sieved through a 300 m sieve.

2.1.4. Water

Water is necessary for the chemical reaction known as "hydration," which involves cement and other materials. The cement hardens and creates a matrix that holds the bricks together after the reaction. For this, potable water was obtained from the Federal Polytechnic, Ado-Ekiti's Civil Engineering Laboratory.

2.2. Methods

2.2.1. Oxide composition of RHA

Oxide composition of RHA was determined using an analytical approach in a lab.

2.2.2. Creation of experimental runs

As stated in Table 1, variables were created using the Response Surface Methodology (RSM) of Design Expert software (version 13) for the manufacturing of Compressed Earth Bricks (CEB). Cement content ranged from 0 to 5 percent, RHA content from 0 to 5 percent, and water content from 20 to 25 percent.

2.2.3. Production and curing of CEB

The ratios of cement, RHA, and water were calculated based on the results of created trial runs. Lateritic soil (4500g), water, RHA, and cement were manually mixed to create CEBs before being fed into a machine that compresses the mixture into bricks. The raw bricks were covered with tarpaulin for 28 days as part of the study's curing procedure to prevent moisture loss.

Table 1 Variables generated for the experimental runs

Variables	**Composition**		
	RHA (%)	**Cement (%)**	**WC (%)**
CEB1	3.75	1.25	21.25
CEB2	0	5	20
CEB3	1.25	3.75	22.5
CEB4	1.25	3.75	21.25
CEB5	5	0	20
CEB6	0	5	25
CEB7	3.75	1.25	22.5
CEB8	1.25	3.75	23.75
CEB9	5	0	25
CEB10	3.75	1.25	23.75
CEB11	0	5	22.5
CEB12	2.5	2.5	22.5
CEB13	5	0	22.5
CEB14	2.5	2.5	23.75
CEB15	2.5	2.5	25
CEB16	2.5	2.5	21.25
CEB17	2.5	2.5	20

2.2.4. Tests

At the ages of 28, 56, and 108 days, the CEBs underwent microstructural and compressive strength tests.The compressive strength test was conducted at the Federal Polytechnic, Ado-Ekiti soil mechanics laboratory to determine the CEB's compressive strength using a compressive strength machine. The compressive strength was calculated using Equation 1.

$$Compressive\ strength = \frac{Crushing\ load}{Area\ of\ specimen}\ N/mm^2 \quad (1)$$

To identify the end products of cement hydration and the pozzolanic reaction of CEBs, a microstructural investigation was performed using a scanning electron microscope (SEM; FESEM model).

3. Results and discussion

3.1. Oxide composition of RHA

The RHA, a local substance, has the main oxides that determine the cementing potentials of any construction material, according to results from Table 2. According to [5] standards, the addition of the three oxides, $SiO_2+Al_2O_3+Fe_2O_3$, is greater than 70%. Consequently, RHA is a pozzolan.

Table 2 Oxide composition of RHA

Oxide	SiO_2	Fe_2O_3	Al_2O_3	CaO	MgO	SO_3	K_2O	Na_2O	M_2O_5	P_2O_5	TiO_2	LOI	SiO_2+ Al_2O_3+ Fe_2O_3
RHA (%)	71.4	3.35	0.52	2.8	2.06	0	1.31	0	0	4.27	0	19.01	75.27

3.2. Compressive strength tests results

Table 3 displays the outcomes of the CEBs' compressive strength tests conducted at the relevant curing days. According to [8] regulations, the compressive strength of CEBs without RHA (5 percent cement) complies with the minimum requirement of 1.65 N/mm^2 for bricks used in building construction. But did not meet the requirements of 1.8 to 2.5 N/mm^2 for unfired bricks at all curing ages, regardless of water content, with the exception of variables 2 and 11 under 28 days, as stated by [6] part 1 & 2. CEB1, 7, and 10 (with 3.75 percent) regardless of water content, 28 and 56 days also met the minimum requirements of 1.65N/mm^2 compressive strength [8] as well as the range of 1.8 to 2.5N/mm^2 as required by [6]. Only 28 days of CEB3 fell within the range of 1.8 to 2.5N/mm^2 as required by [6], however CEB3, 4 and 8 (partially substituted with 1.25 percent RHA) met the minimal standards.

Table 3 Summary of average compressive strength properties of the bricks

Variables	Composition			Avg. Compressive strength (%)		
	RHA (%)	**Cement(%)**	**WC (%)**	**28 days**	**56 days**	**108 days**
CEB1	3.75	1.25	21.25	1.81	1.74	6.51
CEB2	0	5	20	2.37	2.97	5.66
CEB3	1.25	3.75	22.5	2.41	3.09	5.56
CEB4	1.25	3.75	21.25	2.61	3.03	2.61
CEB5	5	0	20	1.63	1.63	2.75
CEB6	0	5	25	5.15	4.71	2.71
CEB7	3.75	1.25	22.5	1.82	2.05	5.78
CEB8	1.25	3.75	23.75	4.55	3.68	4.13
CEB9	5	0	25	1.79	1.98	3.51
CEB10	3.75	1.25	23.75	1.85	2.01	7.29
CEB11	0	5	22.5	2.51	5.36	6.62
CEB12	2.5	2.5	22.5	2.05	2.46	6
CEB13	5	0	22.5	2.42	2.38	6.18
CEB14	2.5	2.5	23.75	2.61	2.62	6.47
CEB15	2.5	2.5	25	2.94	5.24	6.73
CEB16	2.5	2.5	21.25	2.56	2.57	7.96
CEB17	2.5	2.5	20	2.58	2.48	7.2

Although only 28 and 56 days of CEB 9 and 13 fell within the range of 1.8 to 2.5N/mm^2 as prescribed by [6], CEB5, 9 and 13 (partially substituted with 5.0 percent RHA) complied with the minimal standards of 1.65N/mm^2 compressive strength for bricks [7]. Additionally, CEB12, 14, 15, 16, and 17 (partially replaced with 2.50 percent RHA) also fell within the range of 1.8 to 2.5N/mm^2 as required by [6], although only 28 and 56 days of CEB12, 16 and 17 did.

All of the CEBs successfully met the [8] standards, making them usable for building construction. For building bricks of less severe exposure (8.6N/mm^2), moderate severe exposure (15.2N/mm^2), and more severe exposure (17.2N/mm^2) for individual bricks; an average of 5 bricks of less severe exposure (10.3N/mm^2), moderate severe exposure (17.2N/mm^2), and more severe exposure (20.7N/mm^2)—all CEBs failed to meet the minimum compressive strength required by [8].The compressive strength of CEBs with 5% cement content increased with a 20% water content as the curing time progressed, whereas a 22.5% water content produced a decrease in compressive strength from 3.59 N/mm2 to 3.20 N/mm^2 at 56 days but an increase to 7.61 N/mm^2 at 108 days. 25 percent water content worked well, demonstrating that CEBs with 5 percent cement operate best when they had 20 and 25 percent water contents.

3.3. Microstructural analysis results

Figure 1 (a–c) shows the findings of the microstructural properties of the RHA and cement stabilized lateritic soil. These findings demonstrated the morphological development of soil samples stabilized with RHA after curing for 28, 56, and 108 days, respectively. Because of RHA's high pozzolanic character (due to its high amorphous silica content), it was possible to see the formation of a well-developed C-S-H phase throughout the whole matrix [9].

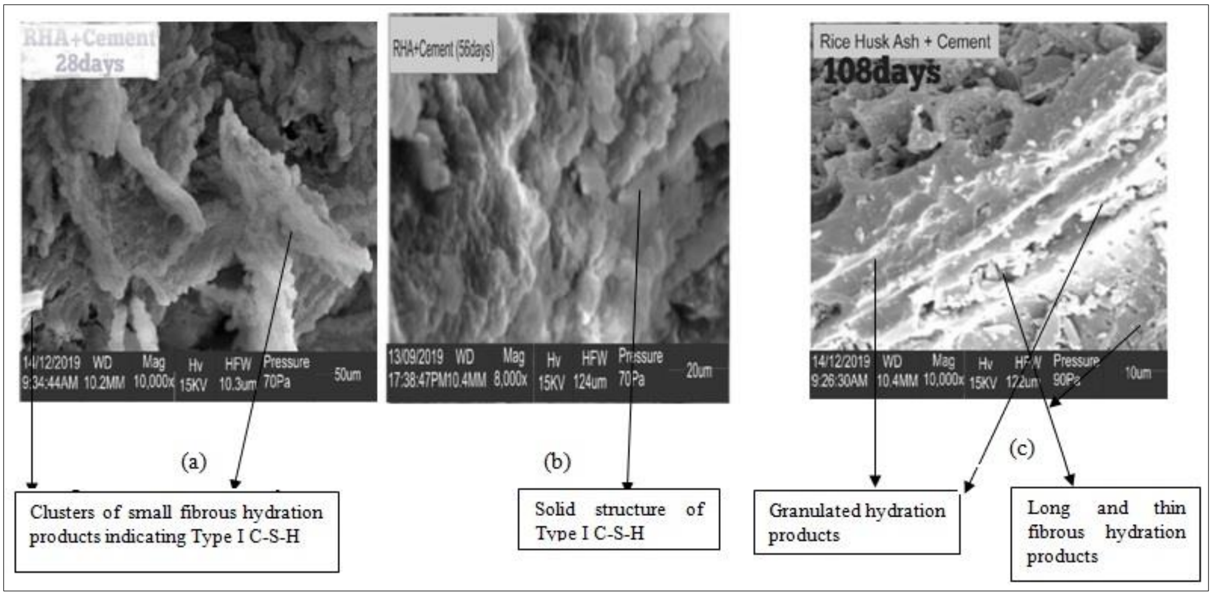

Figure 1 Microstructural analysis of the CEBs for the curing days (a) 28 days (b) 56 days (c) 108 days

C-S-H gel is evidently forming in substantial amounts in Figure 1(a), and an extended crystalline cluster structure is also visible. It has been determined that this collection of tiny fibrous hydration products is Type I C-S-H. Figure 1(b) illustrates how the C-S-H gel gets more evident as the curing period increases and solid Type I C-S-H is formed after 56 days (mature products of cement hydration). At 108 days (Figure 1c), the entire matrix exhibits a well-developed and noticeable hydration product. At this point, several hydration products, including long and thin fibrous, granular, and net-shaped hydration products, are created. [10] has also described this behaviour.

Due to the fact that some of the mixed water is absorbed in its pores, the pore structure of RHA (in terms of pore size and volume of pore) has also been described as playing a significant effect on the hydration process (Le, 2015). Early curing may result in less dilution of the cement hydration in the RHA/Cement mixed soil matrix due to the amount of water absorbed. [11] was of the opinion that the amount of water absorbed into the pores of RHA is released from the pores over time (prolonged curing), when the relative humidity in paste decreases owing to cement hydration, maintaining cement hydration continuously. Additionally, the high alkali component of RHA speeds up RHA's pozzolanic reaction and cement hydration. RHA's pozzolanic activities are more apparent in older age than in younger age (curing). Conclusively, when employed as an additive in conjunction with cement for soil stabilization, RHA performed better as a pozzolanic material.

4. Conclusion

The following conclusions were reached based on the study's findings and analysis:

- RHA, a local substance, is a pozzolan because it contains more than 70% of the three oxides $SiO_2+Al_2O_3+Fe_2O_3$. The outcomes of the microstructural study supported this.
- The pozzolan replacement level and water content increase the bricks' tensile strength. For improved performance, bricks with a 5 percent cement content need 20 to 25 percent water content. When the minimal requirements for compressive strength are met, 1.25 and 3.75 percent RHA work best at water contents of 23.75 to 25 percent.
- It can be determined that the % of RHA replacement and water content are both influences on the stabilized brick's compressive strength capabilities.
- Further research should be conducted.

Compliance with ethical standards

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Conflict of interest statement

There are no conflicts of interest, according to the authors.

References

[1] Kerali AG. Durability of compressed and cement stabilized building blocks [PhD dissertation]. Coventry, England: University of Warwick; 2001.

[2] Sharipah SS. The different scenarios of housing problem in Malaysia [MSc thesis]. Onn, Malaysia: Universiti Tun Hussein; 2011.

[3] Khan IA, Ali MS, Hossain MI. Chemical analysis of ordinary portland cement of bangladesh. Chemical Engineering Research Bulletin. 2011; 12: 7-10.

[4] Bakar BH, Putrajaya RC, Abdulaziz H. Malaysian saw dust ash – improving the durability and corrosion resistance of concrete: Pre-review. Concrete Research Letters. 2010; 1(1): 6-13.

[5] American Society for Testing and Materials (ASTM) C618. Specification for coal fly ash and raw or calcined natural pozzolana for use as a mineral admixture in portland cement concrete. West Conshohocken: Annual book of ASTM; 2005.

[6] British Standard BS 1924. Methods of tests for stabilized soils. 1st ed. London: British Standards Institution; 1990.

[7] Nigeria Building and Road Research Institute (NBRRI). NBRRI materials research and testing manual. 3rd ed. Nigeria: Federal Ministry of Science and Technology; 2011.

[8] American Standard Testing Method (ASTM) C62. Standard specification for building brick (solid masonry units made from clay or shale). West Conshohocken: Annual book of ASTM; 2006.

[9] Mehta PK. Rice husk - a unique supplementary cementing material. Canmet. 1994; 94-1(R): 419-444.

[10] Rahman MA [Internet]. Effect of rice husk ash on properties of brick made from fired laterite soil – clay mix; © 2006 [cited 2022 June 9]. Available from http/www.google.com.

[11] Ramezanianpour A, Mahdikhani A,Ahmadibeni M. The effect of rice husk ash on mechanical properties and durability of sustainable concrete. International Journal of Civil Engineering. 2009, 7(2): 83-91.