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Response Surface Optimization of Rice and Guinea Corn Husk Ash Blended Concrete

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Abstract. Concrete, a fundamental construction material, consists of aggregates, water, cement, and additives. Unfortunately, the large-scale production of cement is a major contributor to carbon dioxide (CO_2) emissions, primarily from the manufacturing process and the consumption of fossil fuels. This not only incurs environmental costs associated with global warming but also depletes vital limestone deposits. To mitigate these issues, this study aims to explore the optimal utilization of Guinea Corn Husk Ash (GCHA) and Rice Husk Ash (RHA) in concrete. This research investigated the chemical properties of GCHA and RHA, and their impact on the compressive and split-tensile strengths of concrete when integrated in various proportions. The study reveals that both GCHA and RHA meet the minimum oxide content requirement of 70% set by ASTM C618, with silicon dioxide (SiO_2) as the predominant oxide. Increasing the content of RHA and GCHA from 5% to 10% improves the concrete's compressive and split-tensile strengths after curing for 56 days. Optimization results indicate that the ideal mix consists of 10% GCHA, 8.5% RHA, and 82.5% cement, yielding a compressive and split tensile strength of 31.34 N/mm² and 3.07 N/mm² respectively. This study thus offers a promising solution for sustainable concrete production by reducing the environmental footprint of cement while enhancing material properties and promoting an eco-friendlier approach to construction.

1.0 Introduction

Concrete is a composite blend of aggregates (fine and coarse), water, cement, and additives. [1]. The cement industry is involved in various strategies to limit, mitigate, and minimize the production impacts on the ecosystem. In terms of strategy, we can note, among other things, the optimization of production processes, the modernization of cement kilns, and the replacement of traditional fossil fuels used for the benefit of renewable energies and industrial waste. The implementation of these solutions, among others, has allowed the cement industry to reduce by 20% CO_2 emissions per ton of cement for the period 1990-2000 [2]. Unfortunately, the production of cement in commercial quantities contributes significantly to the discharge of carbon dioxide (CO_2) into the air during the manufacturing process and through the large burning of fossil fuels. It is on record that the annual production of cement in the world makes up more than 8% of the universal expulsion of CO_2 in the air [3]. To resolve this global challenge, several attempts have been made to incorporate agricultural wastes into concrete since the application of these by-products will not only remove the additional cost of production but also lead to the conservation of the environment. Hence, the innovative method of using blended cement in construction is growing rapidly due to its benefits in saving energy, protecting the environment, saving cost and resource conservation [4]. Today, the trend is to use lightweight materials in construction, enhancing structural stability and reducing costs. Researchers have explored the use of industrial and agricultural byproducts to improve concrete properties and durability. Materials like blast furnace slag, rice husk ash, and guinea corn husk ash have been used as cement replacements [5].

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Rice husk, constituting about 20% of rice's dry weight, lacks nutrients and is primarily composed of cellulose (50%), lignin (25-30%), silica (15-20%), and moisture (10-15%). Considering the worldwide production of paddy rice, which amounts to 750 million metric tons annually, approximately 150 million metric tons of rice husk are produced each year [6]. In 2021, Nigeria's rice production reached approximately 8.34 million metric tons [7]. The effectiveness of rice husk ash (RHA) in enhancing concrete strength depends on various factors such as its amorphous silica content, fineness, mix proportion, and temperature [8]. The pozzolanic reactivity is closely tied to the dissolution of silica from RHA. Previous studies recommend complete burning of rice husk within the temperature range of 500°C to 900°C to achieve the highest content of amorphous silica with a maximum specific surface area of up to 150 m^2/g for RHA particles [9–12]. Adequate grinding, typically ranging from 10 to 30 minutes by a mechanical grinder, is also crucial according to established standards [13-14]. The variability in concrete strength is directly influenced by the filler effect and pozzolanic reactivity of RHA.

Guinea corn is an important food crop produced in large quantities in the savannah belt of Nigeria and West Africa. In developing nations, it is a common practice to dispose of corn husks by either burning them or incorporating them into the soil, often along with corn stalks and leaves. These husks often become solid wastes in landfills thereby polluting the environment [15]. For the guinea corn husks to achieve their pozzolanic properties, the husk has to be calcined within the temperature range 600^{o}C to 650^{o}C [1,14,16] passing through 75 micrometers [17].

Various research has been conducted on the use of guinea corn husk ash (GCHA) and rice husk ash (RHA) in concrete. Odeyemi et al. [1] investigated the possible replacement of naturally obtained coarse aggregates with recycled concrete for the production of concrete where the cement was partially replaced with RHA. The results revealed that the modified mixture prepared with 10% rice husk ash and 100% recycled aggregates had significant improvement in compressive and tensile strengths at all three curing periods of 7, 14, and 28 days. Zareei et al. [2] conducted research work on the properties of Rice Husk Ash (RHA) when used as a partial replacement for Ordinary Portland Cement (OPC) in concrete. The results revealed that the Compacting factor decreased as the percentage replacement of OPC with RHA increased. The compressive strength of the hardened concrete also decreased with increasing OPC replacement with RHA. Saand et al. [4] adopted an experimental approach to the use of rice husk ash as a partial replacement of cement in the production of concrete. Results showed that a 10% replacement of cement with rice husk ash is optimum. At 10% replacement of cement with RHA, the density is increased by 5.02%, the compressive strength by 22.22%, and the split tensile strength by 20.45% in comparison with control aerated concrete. Ramezanianpou et al. [18] conducted some experiments to ascertain the properties of concretes with optimal RHA. The findings indicate that RHA's use as an artificial pozzolanic material has reduced chloride diffusion and increased the durability of RHA concretes. According to Meddah et al. [19], the rise in split tensile strength is attributed to the pozzolanic reaction of nanoscale pozzolan materials, present in 10% RHA. This reaction fills the capillary pores, enhances the compactness of the concrete's microstructure, and enhances its strength characteristics, as mentioned previously. Rice husk ash (RHA) and natural pozzolans (NP) were evaluated by Zunino et al. [20] using compressive strength and durability tests in a multi-level experimental program. RHA increased the strength more than NP, which is well explained by its prominent chemical effect (78%) assessed by isothermal calorimetry and its high amorphous silica content. Both RHA and NP produced significant reductions in the permeability of the concrete, which is mostly explained by the chemical effect. The permeability of concrete is directly proportional to the size of its pores. Cement replacement of 5-25% levels of GCHA showed various improvements and a decline in the physical properties of concrete [15]. It was reported that at a 5% level of GCHA, there was a marked increase in the compressive strength and density values while with further increased levels the reverse was the case [16]. When produced under controlled burning temperature GCHA is very rich with a good percentage of Silica content which attests to its pozzolanic property [21]. In an experimental investigation by Aburime et al. [22], GCHA was used to replace cement in concrete at levels of 0%,

5%, 10%, 20%, 30% and 40% by weight. High-strength concrete reached 49.3 N/mm² at 5% GCHA replacement after 56 days, suitable for heavy loads. Odeyemi et al. [23] found that a concrete mix using 50% river sand and 50% quarry dust performed well in flexural strength for both Bamboo Reinforced Concrete (BRC) and Steel Reinforced Concrete (SRC) at 28 days, with strengths of 12.75 N/mm² and 22.49 N/mm², respectively.

Optimization is the process of making the greatest or most effective use of a situation or resource. It's a method for producing something as perfect, useful, or effective as is practical [24]. A collection of mathematical and statistical methods known as the response surface methodology (RSM) is used in the construction of empirical models to optimize a response that is influenced by numerous independent variables [25,26]. Several researchers have different methods to get an optimized combination of materials for concrete to save resources: Wan Nur Firdaus Wan Hassan et al. [27] researched the best mix ratios for high-strength blended concrete that included micro and nano Palm oil fuel ash (POFA). Statistical models verified and closely matched experimental results. The regression model accurately predicted properties of high-strength blended concrete with 10% micro POFA and 1.50–2.85% nano POFA, meeting optimization criteria for the ideal mixture. Odeyemi et al. [28] evaluated the mechanical characteristics of high-performance concrete using Bamboo Leaf Ash as a partial replacement for cement with varied quantities of superplasticizer and water-cement ratio. The optimal combination of materials at the end of the curing period is 0.360 water-cement ratio at 0.128 % superplasticizer. This resulted in a slump height of 49 mm, compressive strength of 53.61 N/mm^2, and 4.77% water absorption capacity. Adamu et al. [29] used the optimization method to determine the optimum combinations of the Date palm fibre (DPF) and silica fume Response surface methodology (RSM) was used to create accurate mathematical models for predicting concrete properties like density, strength, and water absorption. These models had high accuracy, with errors under 6% when tested experimentally. The optimal combination was found to be 1.6% DPF and 7.7% silica fume. Oyebisi et al. [30] used the central composite design to optimize mix parameters for geopolymer concrete (GPC) with ground granulated blast furnace slag (GGBFS) and corncob ash (CCA), using M30 and M40 concrete grades. They employed Response Surface Methodology (RSM) and found that a combination of 3.2% hair by concrete volume and a hair length of 0.752 inches resulted in an optimal compressive strength of 38.15 MPa according to their mathematical model. The influence of coal fly ash and glass fiber waste on the tensile strength of cement concrete was studied by Marinela Barbuta [31] using central composite design. Coal fly ash was used to replace 10% of the cement in the concrete mix. The study looked at 14 concrete mixtures that had glass fibre added and coal fly ash substituted to increase tensile characteristics. Greater split tensile strength values were found for fibers 19 to 28 mm in length and 1 to 1.5% dose, as well as greater flexural strength values for fibers longer than 12 mm.

The existing research only explored the effects of guinea corn husk ash (GCHA) and rice husk ash (RHA) individually in concrete. However, limited information exists on how using GCHA and RHA together might have combined benefits. Additionally, there is a lack of knowledge regarding the best proportions of GCHA and RHA for better concrete performance. In view of this, this study aims to evaluate the effect of combining guinea corn husk ash and rice husk ash on the mechanical properties of hardened concrete and to determine the optimal combination of both for concrete production.

2.0 Materials and Methodology

2.1 Materials

The materials used in this research project include Portland Limestone Cement (PLC) of grade 42.5R conforming to BS 8500-2 [32]; fine aggregates obtained from Asa River, Ilorin, passing through a 4.75mm sieve and conforming to BS 8500-2 [32] and with Coefficient of uniformity is 2.8 and Coefficient of curvature is 1.43; coarse aggregates varying from 20mm to 6.75mm, conforming to ACI Committee 363 [33], and obtained from Ramsat Marble and Granites, Ilorin; water, which is potable and conforms to BS EN 12620 [34]. Guinea corn husks and rice husks were initially collected

as agricultural waste at Alao Farm in Kwara State, resulting from the harvesting of Guinea corn. To prepare them for further processing, these husks underwent sun-drying to remove moisture content. The calcination was done at a temperature of 650^0C, a process that occurred at the Fabrication Workshop within the Department of Mechanical Engineering at the Institute of Technology, Federal Polytechnic Offa. Subsequently, the ashes were refined into finer particles using a milling machine and then passed through a No. 90 μm sieve, all following the guidelines outlined in ASTM D7928 [35].

The materials were tested for their specific gravity, water absorption, fineness modulus, and normal consistency, as detailed in Table 1. Potable and uncontaminated water with a pH value of 7.5 was used for the concrete mix.

Table 1. Physical properties of aggregates

Description	PLC	Fine Aggregates	Coarse Aggregates
Specific Gravity	2.7	2.66	2.63
Water Absorption Capacity (%)		2.6	0.6
Fineness Modulus		3.76	
Normal Consistency (%)	30		
Setting Time of Cement			
Initial setting time (mins)	113	-	-
Final setting time (mins)	323	-	-

2.2 Methodology

2.2.1 Mix Design

The experimental setup was designed using Design Expert (Version 13), where an RSM in a Central Composite Design (CCD) was used to optimize the Guinea corn ash and rice husk ash. The CCD requires that the combinations would have to be designed before proceeding to the laboratory. Three independent variables, Guinea corn and rice husk ashes (5-10%) and cement (80-90%) with 17 experimental runs for compressive and split tensile strength were considered in this study. The batching of the concrete was by weight and the adopted mix ratio per cubic meter of concrete is shown in Table 2. Table 2 also shows the number of experimental runs, and the weights of GCHA, RHA, and cement used for each run at a constant water-binder ratio of 0.5. All other components of the concrete were kept constant. A total of one hundred and fifty-three cube and cylinder samples were cast. The concrete production involved the gradual addition of water to achieve a homogenous mixture of cement, aggregates and ashes for 5 minutes. The cubes were prepared with a size of 100 x 100 x 100 mm, while the cylinders have a diameter of 100 mm and height of 200 mm. The freshly mixed concrete was placed in moulds, and thorough compaction was carried out to eliminate air voids. The specimens were cured for 7, 28, and 56 days. After curing, mechanical tests (compressive strength and split tensile strength) were conducted on the samples.

Fig.1 displays the design interface of the design expert. The cubical and cylindrical samples are shown in Fig.2.

Table 2. Mix ratio per cubic metre of concrete

Run	GCHA (kg)	RHA (kg)	Cement (kg)	Fine Aggregate (kg)	Coarse Aggregate (kg)
1	11	21	176	416	832
2	16	16	176	416	832
3	16	16	176	416	832
4	21	16	165	416	832
5	10	10	176	416	832
6	21	21	176	416	832
7	21	16	186	416	832
8	16	10	186	416	832
9	21	10	176	416	832
10	16	21	165	416	832
11	10	16	165	416	832
12	16	16	176	416	832
13	16	16	176	416	832
14	16	21	186	416	832
15	16	10	165	416	832
16	16	16	136	416	832
17	10	16	186	416	832

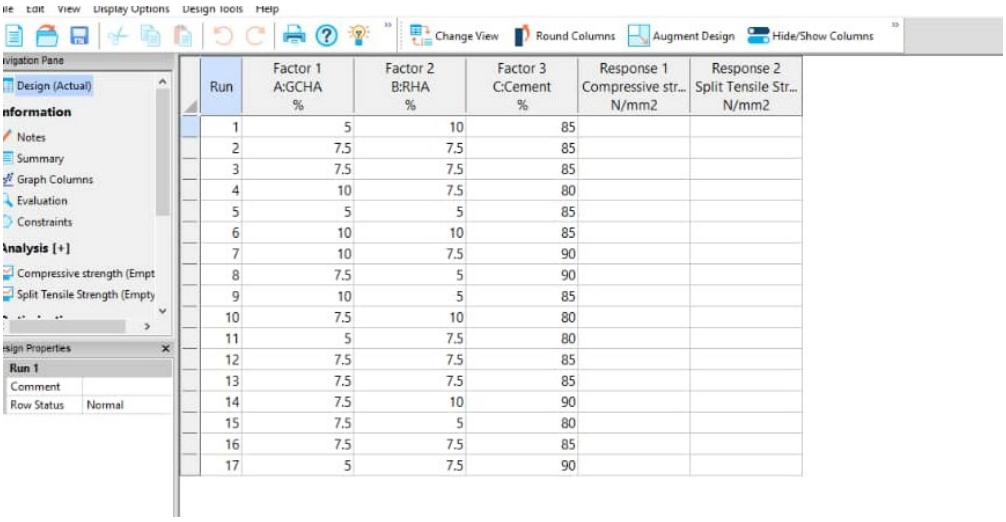


Fig. 1. Design expert interface



Fig. 2. Cubical and cylindrical samples

2.2.2 Experimental Programme

2.2.2.1 Chemical composition, crystallinity, and Micrograph of GHCA and RHA

Scanning Electron Microscopy (SEM) was employed to inspect GHCA and RHA samples under specific conditions. These samples were sized, coated with conductive platinum, and introduced into a vacuum chamber. Elemental composition was ascertained through the use of EDS detectors, aiding in phase identification, and conforming to ASTM E1621 [36]. For XRF analysis, rice and guinea corn husk ash samples were crushed and transformed into pellets. An X-ray tube emits X-ray line spectra for up to ten elements during this analysis. X-ray diffraction necessitates the compaction of samples into grids, which are then scanned using a Rigaku D/Max-lllC X-ray diffractometer. These tests were conducted at the ROLAB research and diagnostic laboratory in Oyo State, adhering to ASTM E1621 [36] and ASTM E1382 [37] standards.

2.2.2.2 Mechanical Properties of Concrete Containing GHCA and RHA

The compressive strength test which conformed with the stipulations in BS EN 12390-3:2019 [38] was conducted using a STYE-2000 Analogue type compression testing machine with serial number 131010 supplied by Okhard Machine Tools, Lagos, Nigeria. The test measured the blended concrete's load-bearing capacities. Using Equation 1, the compressive strength was calculated. As shown in Fig. 3, the test was performed at the Kwara State Ministry of Works' Works and Transport laboratory.

$$\text{Compressive strength} = \frac{\text{Maximum load (kN)} \times 1000}{\text{Cross-sectional Area (mm}^2\text{)}} \quad (1)$$



Fig. 3. Compressive Strength Test

The Split-Tensile Strength Test assessed the concrete's tensile strength perpendicular to the applied load on the blended GHCA and RHA concrete using the same equipment used for the compression test. The tests followed the specifications in BS 1881 117-83 [39]. The strength of the specimens was determined using Equation 2. Fig. 4 shows one of the samples in the machine.

$$Splitting\ tensile\ strength\ (T) = \frac{2P}{\pi\, LD} \tag{2}$$



Fig. 4. Split-Tensile Strength test

3.0 Result and Discussions

3.1 Microstructural properties

3.1.1 Chemical composition of both rice husk ash (RHA) and guinea corn husk ash (GCHA).

Table 3 displays the chemical composition of both rice husk ash (RHA) and guinea corn husk ash (GCHA). In this research, the total oxide content of SiO_2, Al_2O_3, and Fe_2O_3 in RHA and GCHA is found to be 78.47% and 70.58%, respectively. Notably, silicon dioxide (SiO_2) constitutes the highest percentage of oxide composition. This meets the minimum requirement of 70% specified by ASTM C618 [40] standards for supplementary cementitious materials, which aligns with the findings of Odeyemi et al. [23,41].

Table 3. Chemical composition of RHA and GCHA

Oxides	RHA (%)	GCHA (%)
SiO_2	73.5	55.4
Al_2O_3	3.22	14.90
Fe_2O_3	1.75	0.28
MnO	0.67	0.03
CaO	4.35	1.08
P_2O_5	8.75	0.25
K_2O	5.35	2.02
TiO_2	0.26	0.01
SO_3	0.15	0.12
Na_2O	0.02	0.18
Ba	0.59	0.64
Ce	0.20	0.35
Rb	0.02	0.02
Zn	0.10	0.12
Cr	0.15	0.10
Cu	0.12	0.14
Ni	0.12	0.10
LOI	0.02	10.60

3.1.2 SEM images

The SEM image of RHA (Fig. 5) at 20 kV and 8000x magnification shows dense, irregularly shaped particles with high silica content, indicating porosity. Micro-particles are closely packed in the polymer matrix.

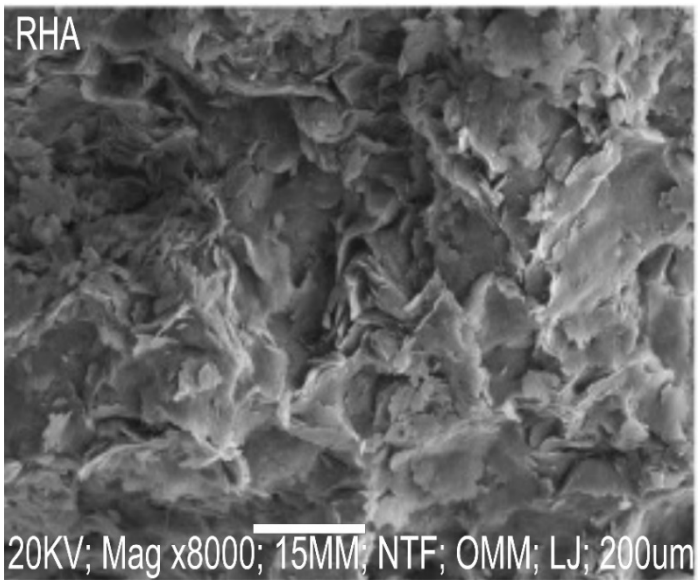


Fig. 5. SEM image of RHA

The SEM image of GCHA (Fig.6) at 1000x magnification reveals stacked micro-particles forming clusters with honeycomb-like texture and pores, suggesting significant porosity. Some rod-like structures are present, potentially improving certain concrete properties.

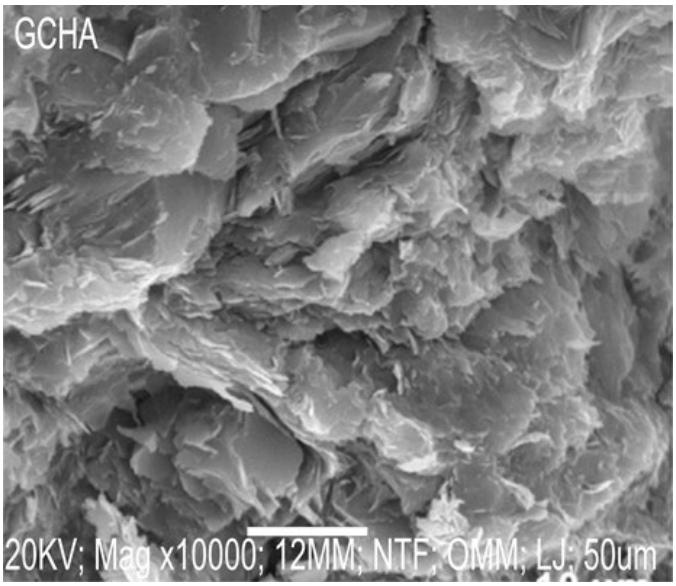


Fig. 6. SEM image of GCHA

3.1.3 XRD analysis result

Fig.7 shows the XRD results for RHA. A strong silica peak at $2\theta = 22^0$ (intensity > 1800) indicates its pozzolanic properties. Silica-rich materials react with $Ca(OH)_2$ in water to form C-S-H gel, enhancing concrete strength and durability. High silica content improves concrete strength. Fig.8 displays XRD results for GCHA. A prominent silica peak at $2\theta = 25^0$ (intensity > 2500) is evident, surpassing RHA's intensity.

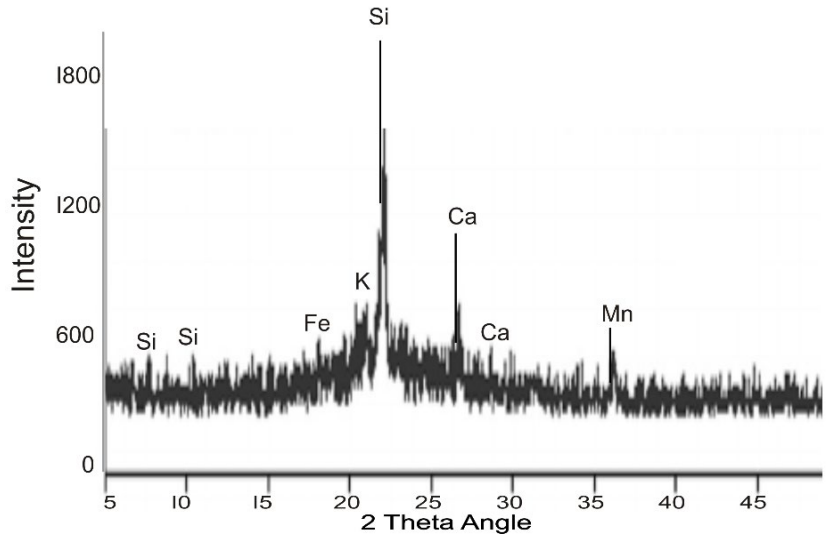


Fig. 7. XRD graph for RHA

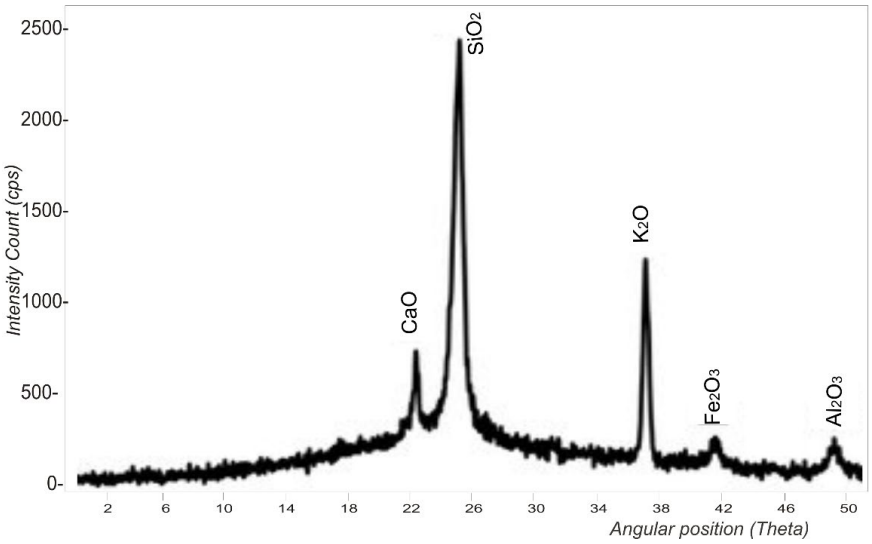


Fig. 8. XRD graph for GCHA

3.2 Mechanical Properties

3.2.1 Compressive strength result

In Fig. 9, a three-dimensional depiction illustrates the correlation between compressive strength and the levels of Rice husk ash (RHA) and Guinea corn husk ash (GCHA) after 7 days of curing the concrete samples. As the quantity of RHA increased, there was a corresponding increase in the compressive strength of the concrete. Likewise, the increase in the percentage inclusion of the GCHA in the concrete up to 7.5% increased the compressive of the concrete. Afterwards, the strength declined. This could be attributed to the fact that the effect of pozzolans are felt as the age of the concrete increases [42-43].

In Fig. 10, the three-dimensional diagram of the correlation between compressive strength and the quantities of rice husk ash and guinea corn husk ash at 28 days of curing shows an increase in strength compared to the seven days results. It can be observed that as the proportion of rice husk and guinea corn husk ashes rises, there is a corresponding increase in the compressive strength of the concrete.

The same trend as was observed in the 28th-day result was observed on the 56th day of curing the concrete. At a constant percentage of either the GCHA or the RHA, an increase in either of the pozzolans resulted in a corresponding increase in the compressive strength of the concrete, which correlated with the findings of Ndububa [16] and Ramezanianpour [18].

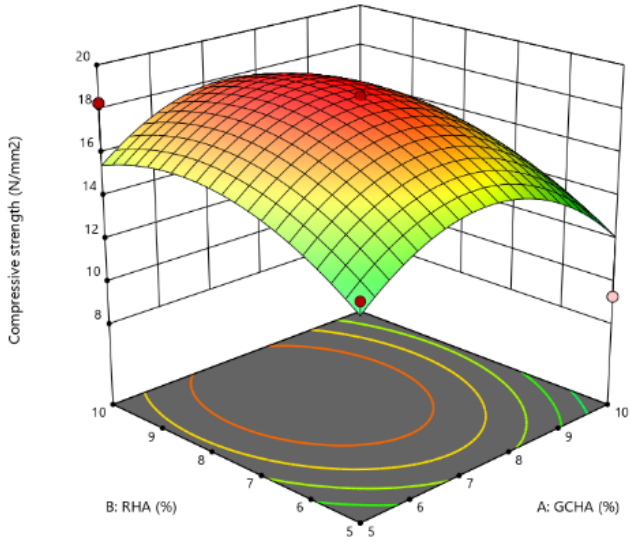


Fig. 9. 3D relationship between Rice husk ash and Guinea corn husk corn ash with Compressive strength after 7 days

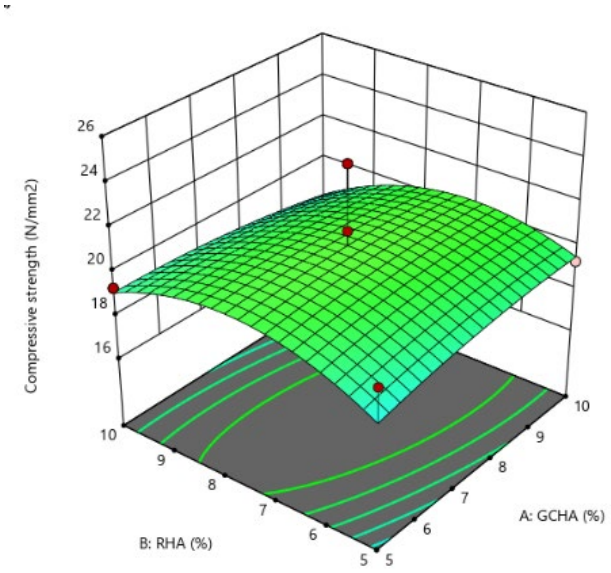


Fig. 10. 3D relationship between Rice husk ash and Guinea corn husk corn ash with compressive strength after 28 days of curing

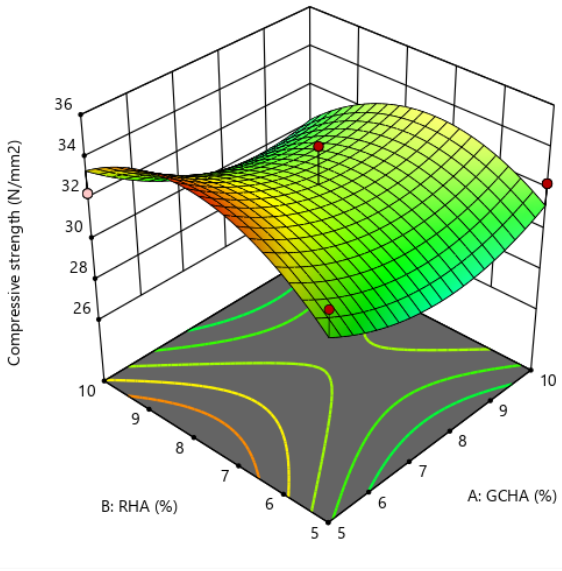


Fig. 11. 3D relationship between Rice husk ash and Guinea corn husk corn ash with compressive strength after 56 days

3.2.2 Split tensile strength result

Fig. 12 demonstrates a 3D relationship between Rice husk ash and Guinea corn husk ash with tensile strength after 7 days. Increasing the amount of Rice husk ash or Guinea corn husk ash results in higher tensile strength.

Fig. 13 shows the progression in the tensile strength after 28 days of curing the concrete. There was a rise in the tensile strength when compared to the result plotted for the seven-day observation. Reducing the RHA content led to decreased tensile strength. At a constant percentage of RHA, a gradual drop in strength was observed as the percentage of GCHA increased. This, however, changed as the percentage inclusion of GCHA went beyond 7.5% inclusion. This could also be attributed to the fact that the effect of pozzolans are felt as the age of the concrete increases [23,42].

Fig. 14 displays tensile strength results after a 56-day curing period. As the proportion of rice husk ash in the mix increases, tensile strength rises. This finding relates to the results reported by Al-Alwan [44]. Similarly, higher guinea corn husk ash content corresponds to increased concrete tensile strength. This is due to the high silica content of the ash.

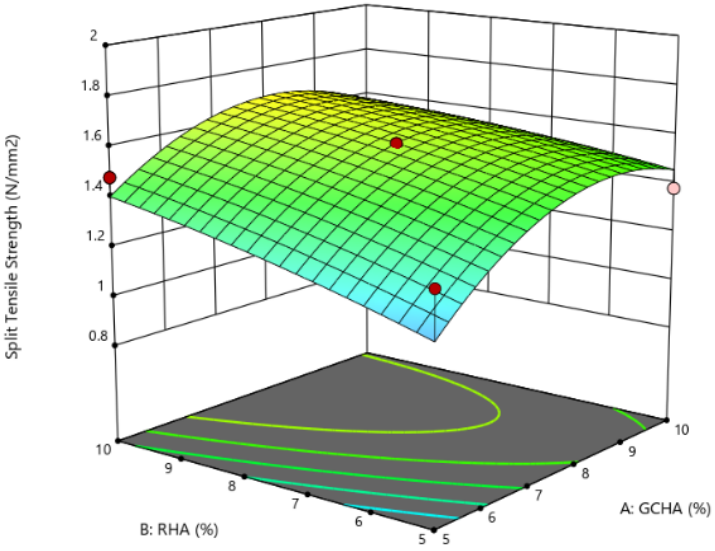


Fig. 12. 3D relationship between Rice husk ash and Guinea corn husk corn ash with Tensile strength after 7 days

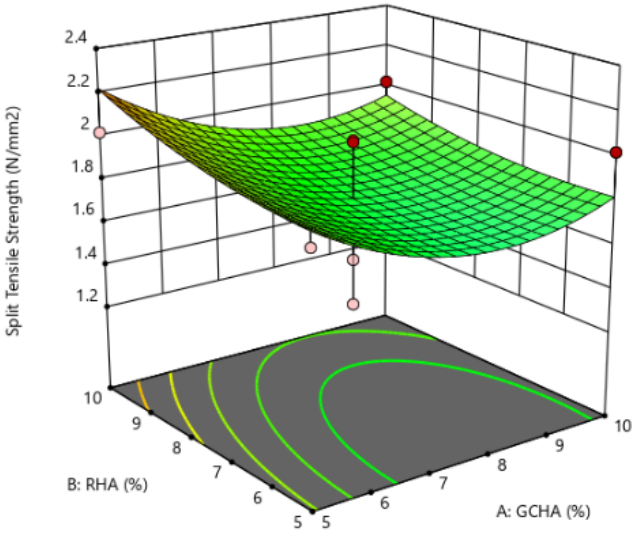


Fig. 13. 3D relationship between Rice husk ash and Guinea corn husk corn ash with tensile strength after 28 days

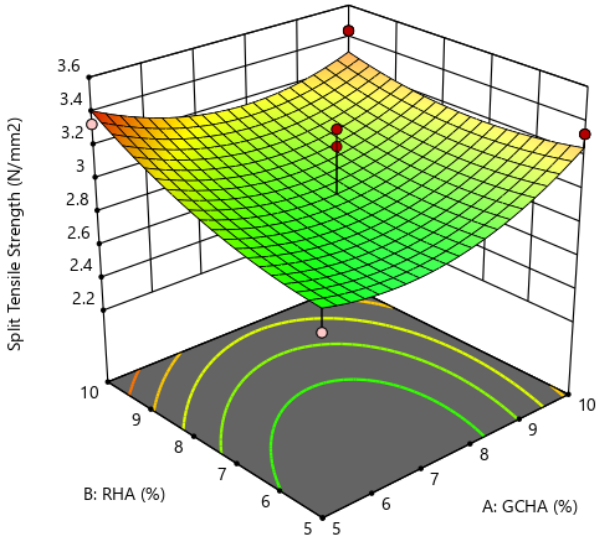


Fig. 14. 3D relationship between Rice husk ash and Guinea corn husk corn ash with tensile strength after 56 days

3.3 Model equations and optimization of materials for the concrete

Quadratic models were developed for the compressive and split tensile strengths of the hardened concrete after 56 days of curing the samples. The model for the compressive and split tensile strengths has p-values of 0.0173 and 0.0186 respectively and R^2 values of 0.8766 and 0.8737 respectively while their adjusted R^2 values are 0.7180 and 0.7112 respectively indicating that both models are significant for predicting the compressive and split-tensile strengths of the concrete. The models are presented as Equations 3 and 4 for the compressive and split-tensile strengths of the concrete, respectively.

$$Compressive\ strength = -0.92A - 0.1663B + 2.75C + 0.9325AB - 0.7575AC - 0.1BC - 0.62A^2 + 0.3725B^2 - 0.8025C^2 + 32.33 \quad (3)$$

$$Split - tensile\ strength = 0.245A - 0.1237B - 0.1638C + 0.1AB + 0.02AC - 0.0275BC - 0.1113A^2 - 0.1588B^2 - 0.2887C^2 + 3.33 \quad (4)$$

Where A is Guinea corn husk ash, B is rice husk ash, and C is cement.

After a 56-day curing period, an optimization process was carried out with the objective of maximizing the use of rice husk and guinea corn husk ashes while minimizing the cement content in the concrete. Fig. 15 shows the optimized result of 10% guinea corn husk ash, 8.5% rice husk ash, and 82.5% cement. This resulted in a compressive strength of 31.34 N/mm² and split tensile strength of 3.07 N/mm², meeting BS EN 12390-3:2019 and BS EN 12390-6:2009 requirements. Both results have desirability values greater than 70%. The optimized compressive strength of 31.34 N/mm^2 is almost the same as the results presented for concrete containing 7% and 14% RHA at 0.5 water-cement ratio reported by Asad Al-Alwan et al. [44]. The optimized split-tensile strength of 3.07 N/mm^2 is also close to the results obtained for the tensile strengths reported for the samples obtained by the same authors (the authors did not work on split tensile strength).
The optimized compressive strength obtained in this study is also higher than the 30.42 MPa at 5% Wheat Straw Ash (WSA) combined with 5% of RHA reported by Bheel et al. [45]. The split-tensile strength in this study is, however, lower than the highest splitting tensile strength of 3.52 MPa at 5% of WSA along with 5% of RHA reported by the same author.

The optimized compressive and split tensile strengths are, however, lower than the value of 35.86 N/mm^2 and 4.26 N/mm^2 respectively reported by Bheel et al. [46] when the authors used 10% RHA only for their concrete samples.

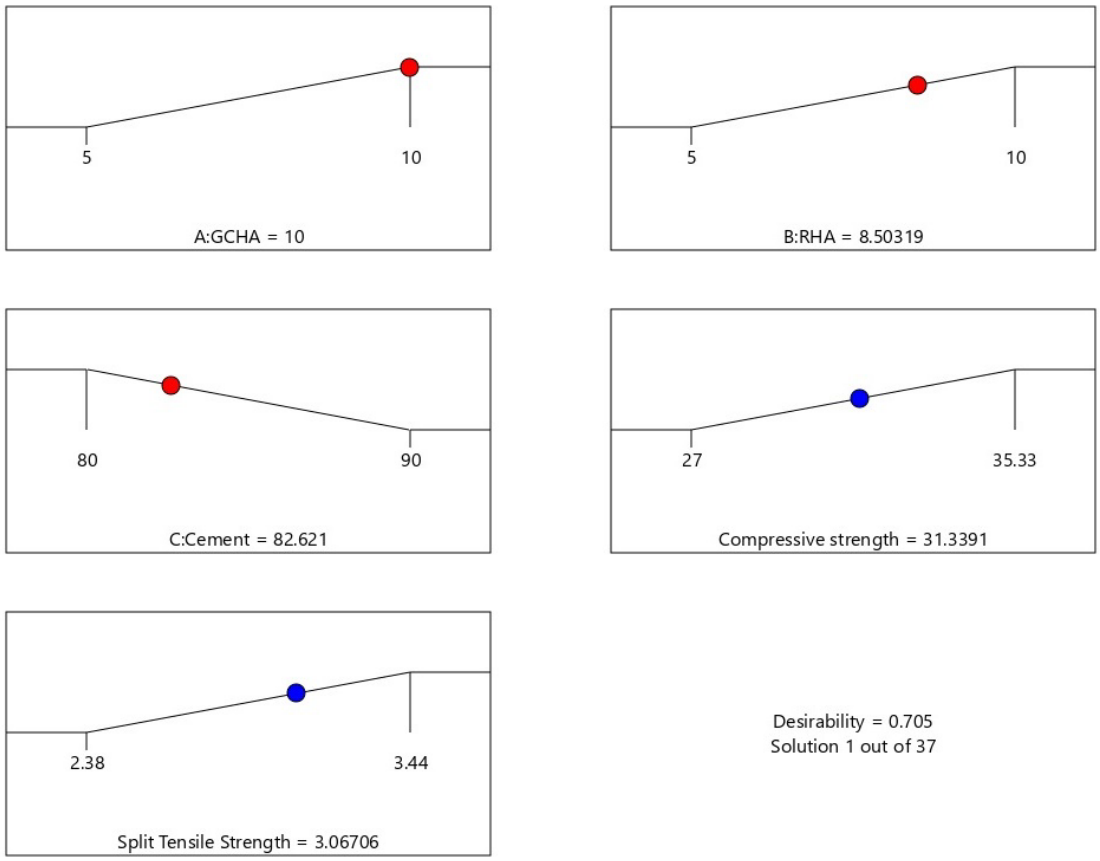


Fig. 15. Optimized results

3.4 Validation of results

The relationship between predicted and experimental results for the compressive and split-tensile strengths of the concrete after 56 days of curing is shown in Figures 16 and 17. Both have a linear relationship indicating the closeness between the predicted and the actual results from the experiments.

The compressive and split-tensile strengths' respective Adequate Precision values, 7.63 and 6.31, are higher than 4.0 for both investigations. This shows that the signal-to-noise ratio is adequate, indicating that the model can be trusted to guide the design space, hence confirming the accuracy of the model equations.

The R^2 value indicates the proportion of the variance in the dependent variables that can be collectively explained by the independent variables. The closer to unity that the value is the more reliable they are. Thus, the R^2 of 0.8766 and 0.8737 for the compressive and split tensile strengths validate the reliability of the results obtained.

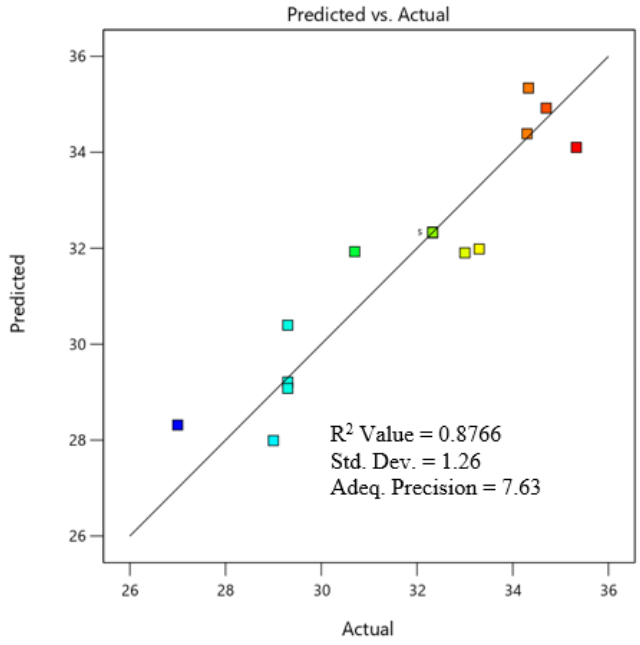


Fig. 16. Predicted vs Actual results for compressive strength

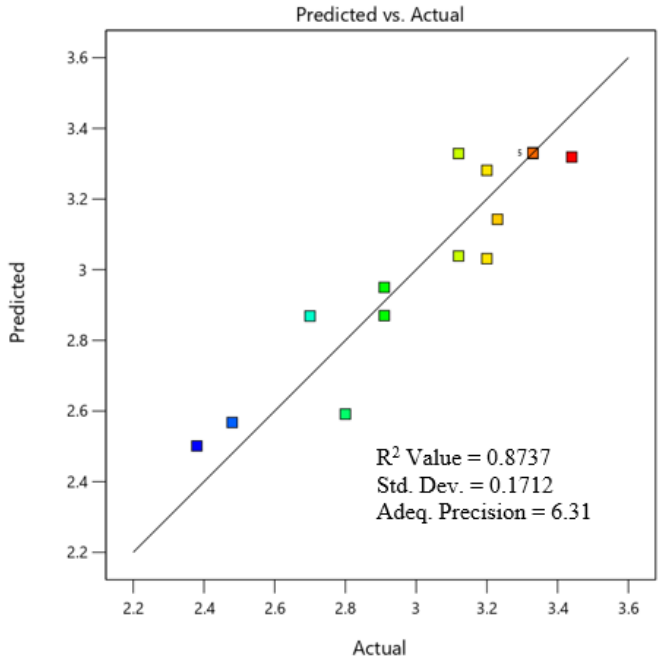


Fig 17. Predicted vs Actual results for split-tensile strength

4.0 Conclusions

The following conclusions were drawn from the study:

1. Rice husk ash (RHA) and guinea corn husk ash (GCHA) have a total oxide content of 78.47% and 70.58%, respectively, with silicon dioxide (SiO_2) being the most abundant oxide, meeting the minimum requirement of 70% set by ASTM C618 [40] standards for supplementary cementitious materials.
2. The increasing percentage of RHA and GCHA dosage from 5% to 10% increases concrete compressive strength for the days of curing considered in the study.
3. More rice husk ash increased tensile strength, and increasing guinea corn husk ash content enhances concrete strength after 56 days of curing.

4. The optimized combination was 10% guinea corn husk ash, 8.5% rice husk ash, and 82.5% cement. This gave a compressive strength of 31.34 N/mm² and split tensile strength of 3.07 N/mm².
5. The research proposes the utilization of rice husk ash and guinea corn husk ash in construction as a means to improve the performance of concrete, providing an eco-friendly alternative for practical construction situations. This inventive strategy for sustainable construction practices has the potential to reshape the norms of concrete technology, advocating for environmentally conscious approaches within the industry.

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