Turkish Journal of Agricultural Engineering Research

https://dergipark.org.tr/en/pub/turkager
https://doi.org/10.46592/turkager.1387174

Turk J Agr Eng Res
(TURKAGER)

ISSN: 2717-8420
2023, 4(2), 239-250

Research Article

Utilization of Plant Waste Materials as a Partial Replacement of Cement and Fine Aggregates in Concrete Production

Otaghogho Zion TACHERE[a]ID, Onyekachukwu Nicklette AKPENYI-ABOH[b*]ID, Ovie Isaac AKPOKODJE[a]ID, Oderhowho NYORERE[c*]ID

[a]*Department of Civil and Water resources Engineering, Delta State University of Science and Technology, Ozoro, NIGERIA*
[b]*Department of Mechanical Engineering, Delta State University of Science and Technology, Ozoro, NIGERIA*
[c]*Department of Agricultural Engineering, Delta State University of Science and Technology, Ozoro, NIGERIA*

(*): Corresponding Author: ziontachere@gmail.com

Article Info

Received: 07.11.2023 **Accepted:** 04.12.2023 **Published:** 31.12.2023

ABSTRACT

The research focused on possibility of producing high quality concrete by the way of adding plant waste materials like sugarcane bagasse ash (SBA), rice husk (RH) and cassava starch (CS) to concrete mixtures. Varying percentages of SBA (0, 5, 10, 15% - weight of the cement), rice husk (0, 5, 10, 15% - weight of the fine aggregates) and cassava starch (0, 1, 2, 3% - weight of the cement) were incorporated into the concrete mixtures design. Comprehensive laboratory investigations were done on the concrete's workability (slump), density and mechanical strength, to establish the impact of these organic materials on the mechanical parameters of the concrete produced. The laboratory test results show that SBA and CS augmented the concrete slump rate whereas, the rice husk retarded the concrete's workability. The result of the density indicated that the rice husk and SBA reduced the concrete's density; however, the cassava starch caused substantial increment in the concrete's density. On the concrete mechanical properties, it was noted from the results that the compressive strength was boosted by the incorporation of SBA and CS. The maximum compressive strength (23.7 N mm^{-2}) was recorded through by substituting the cement with 10 and 2% of SBA and cassava starch respectively, in the presence of 10% RH as partial replacement of the sand. This study findings had revealed the potential of SBA, rice husk and cassava starch combinations in the right mixture design, to produce light-weight concrete material having sustainable high compressive strength.

Keywords: *Concrete, Environmental sustainability, Green admixture, Mechanical properties, Sustainable cement*

To cite: Tachere OZ, Akpenyı-Aboh ON, Akpokodje OI and Nyorere O (2023). Utilization of Plant Waste Materials as a Partial Replacement of Cement and Fine Aggregates in Concrete Production. *Turkish Journal of Agricultural Engineering Research (TURKAGER), 4(2): 239-250.* https://doi.org/10.46592/turkager.1387174

INTRODUCTION

Concrete, a cement matrix particulate composite product is widely used in the building industry. Concrete is known for its considerable strength and resilience, making it an appropriate material for numerous structural applications. Apart from the substantial compressive strength of concrete, it is high resistance to ultraviolet radiation, nuclear reaction, and most chemical exposure (Amalraj and Ilangovan, 2023). Concrete has flexibility characteristic with excellent mechanical properties. The versatility of concrete makes it useful in several domestic and industrial structural applications, such as radiation shields, bridges, dams, industrial floors, towers, rigid pavement, vibration dampener, and management structures (Nishant *et al.*, 2016; Akpokodje *et al.*, 2019).

The mechanical behaviors of concrete are influenced by the types of materials used for its' production, and their mixing ratio. The main primary materials used to produce concrete are-cement, water, fine aggregates (commonly referred to as sand) and coarse aggregates commonly referred to as gravel), and in some cases secondary materials (admixtures) and reinforcement materials (steel rods, fibres) are introduced into the concrete to increase its mechanical properties and environmental friendliness (Eboibi *et al.*, 2022; Niaki *et al.*, 2022; Amalraj and Ilangovan, 2023). Apart from enhancing the workability of the fresh concrete, water aids complete hydration reaction of the cement. But excessive volume of water caused the formation of lower quality of tobermorite gel, leading to the production of concrete with lower compressive strength (Salem and Pandey, 2017; Akpokodje *et al.*, 2021). To achieve concrete with preferable compressive strength, the water-cement ratio, primary and secondary materials should be carefully adjusted and monitored to attain the specific requirements of the concrete produced.

Cement is the main binding material used in concrete production, but there are several research into substituting this inorganic material (cement) with sustainable green (organic) materials, to provide strength and durability to concrete (Memon *et al.*, 2022). Concrete production comes with a substantial environmental hazard, as about 5% of the world's greenhouse gases (GHS)-that are responsible for global climate change, comes from cement and coarse aggregates production, which are primary materials used for the concrete production (Lee *et al.*, 2018). The utilization of ashes produced from agricultural materials, as supplementary cementitious materials during concrete production, is a great environmentally sustainable and economically viable approach to address the organic waste disposal issues (Akram *et al.*, 2009).

Research into innovative admixtures and green materials for concrete production is ongoing, since civil engineering construction industry tends to seek more sustainable and cost-effective materials for building construction (Usman *et al.*, 2016; Shafiq *et al.*, 2018; Saleh *et al.*, 2020). Sugarcane bagasse is a fibrous residue obtained through the processing of sugarcane into sugar and related sugarcane products. The ash obtained through the combustion of the bagasse is used as a green substitute for cement during concrete production. It is essential that the volume of the admixture (sugarcane bagasse ash-[SBA]) used for the concrete is not high enough to reduce the compressive strength and stability of the concrete produced (Memon *et al.*, 2022). Literature review revealed several reports on the application of SBA in concrete technology, as potential partial replacement material for cement during concrete production (Chusilp *et al.*, 2009; Xu *et al.*, 2018; Anjos *et al.*, 2020). However, related literature search revealed no information on the hybridization of SBA, cassava starch and rice husk during concrete production, to create concrete with realistic physical, electrical, thermal and mechanical properties. Therefore, the aim of this study is to produce high strength sustainable concrete through hybridization of SBA, rice husk and cassava starch. The successful utilization of agricultural waste materials in concrete technology will enhance effective waste management and production of environmentally friendly concrete structures.

MATERIALS and METHODS

Materials

A Portland Limestone Cement having a grade of 42.5 was used in this study. This cement is in compliance with Nigerian Industrial Standards (NIS) and Standards Organization of Nigeria (SON) guidelines, and it is used for several civil engineering applications.

Furthermore, the fine aggregates used for the concrete production were riverbed sand commonly called “sharp sand”; while the coarse aggregates used were granite of size 19 mm, obtained from the quarry were used for the concrete produced in this study. Additionally, cassava starch (CS), rice husk (RH) and sugarcane bagasse ash (SBA) used as admixtures were obtained from farm structure laboratory of the Department of Agricultural Engineering, Delta State University of science and Technology, Ozoro, Nigeria.

Methods

Concrete production experimental plan

Seven sets of concrete (6 sets were modified, and 1 set was the control) were produced in this research, in variance to previous mixture ratio of Memon *et al.* (2022) and França *et al.* (2023). The modification is done through the addition of organic starch to the concretes to enhance their engineering properties. Table 1 showed the quantity of the primary and secondary constituents of the concrete. All the materials quantities were measured based on a mix ratio of 1:2:4. The SBA and cassava starch quantity were percentage weight of cement, while the rice husk volume was percentage weight of the fine aggregates.

Table 1. *The concrete production plans.*

Samples code	Cement volume (%)	SBA volume (%)	Fine aggregates volume (%)	Rice husk volume (%)	Coarse aggregates volume (%)	Cassava starch (%)
GC 0 (control)	100	0	100	0	100	0
GC 1	95	5	95	5	100	0
GC 2	90	10	90	10	100	0
GC 3	85	15	85	15	100	0
GC 4	94	5	95	5	100	1
GC 5	88	10	90	10	100	2
GC 6	82	15	85	15	100	3

Concrete mixture design
A concrete mixture design of ratio 1:2:4 was adopted for this research, while a water-cement ratio of 0.6 was implemented during the course of the concrete production. The mix ratio represents the proportions of different ingredients in the concrete mix, and batching my mass was used to measure the amount of the different constituents used for the concrete production. These mix ratios will have significant effect the strength properties and workability of the concrete (Uguru *et al.*, 2022).

Concrete production
The fresh concrete was poured into a pre-prepared (oiled) mould of dimensions 0.15 x 0.15 x 0.15 m in three equal layers. After each layer was poured into the mould, it was vigorously rammed 25 times using a 0.016 m ramming rod, to compact the concrete and remove any voids. Then the surface of the mould was smoothed and leveled by using a hand trowel (Uguru *et al.*, 2022).

Curing
The concrete was cured through the total immersion in water under environmental conditions (temperature 31±6°C and 82±9% relative humidity) as described by Uguru *et al.* (2022) in a curing tank at ambient environmental conditions.

Laboratory analysis
Particles size grading
The sharp sand particle size grading was conducted in harmony with ASTM C136 (2006) approved procedures. Thereafter, the calculation of the coefficient of uniformity (Cu) of the sand was done through the formula shown in Equation 1. Coefficient of uniformity is a factor that helps to evaluate the uniformly the soil particles distributed within soil mass, and how the soil can be graded (Eboibi *et al.*, 2022).

$$Cu = \frac{D_{60}}{D_{10}} \quad (1)$$

Where: D_{60} is the volume of 60% finer soil particles, and D_{10} is the volume of 10% finer soil particles.

Slump test
The slump test (workability) of the concrete was determined in accordance to the ASTM C143 (2017) approved procedures.

Concrete density
The concretes' density was determined at 28th curing day in accordance with ASTM C642 (2021) approved standard. An electronic weighing balance and caliper were used to measure the mass and dimensions of the concrete cube respectively. Thereafter, the density was calculated through the expression in Equation 2, as described by Suhad *et al.* (2016).

$$Density\ (kg\ m^{-3}) = \frac{Mass\ (kg)}{Volume\ (m^3)} \quad (2)$$

Concrete compressive strength test

The compressive strength-of the most essential mechanical behavior of a concrete was measured in accordance with ASTM C39M (2014) approved procedures, by using a Stye-2000 Ctm Digital Hydraulic Compression Testing Machine-Model NO: STYE-2000 manufacture in China (Figure 1). At the end of each concrete cube testing, to calculate the concretes' compressive strengths, the expression in presented Equation 3 as described by Akpokodje *et al.* (2021) was used. The test (for each concrete set) was done in triplicate and the average value recorded.

Figure 1. *The crushing of the concrete cube.*

$$Compressive\ strength = \frac{Force}{Area} \tag{3}$$

Statistical analysis

The results obtained from the all-laboratory tests were analyzed statistically through the use of appropriate charts and tables. Each test was conducted in triplicate, and the mean value recorded.

RESULTS AND DISCUSSION

Particle size grading (PSD)

The PSD result of riverbed sand used in this study is presented in Figure 2. Based on the Cu and Cc values (Cu= 5.46 and Cc= 1.25), the fine aggregates used for concrete production fall within the range for "Poorly graded" fine aggregates according to the Unified Soil Classification System (USCS) grading system. According to USCS (2015), any soil having Cu greater than 6 and the fine content less than 5% is considered "Well Graded sand" (USCS, 2015). Generally, poorly graded soil tends to produce concrete of lower quality (poor mechanical strength) when compared to its counterparts made from well graded soil (Akpokodje *et al.*, 2021).

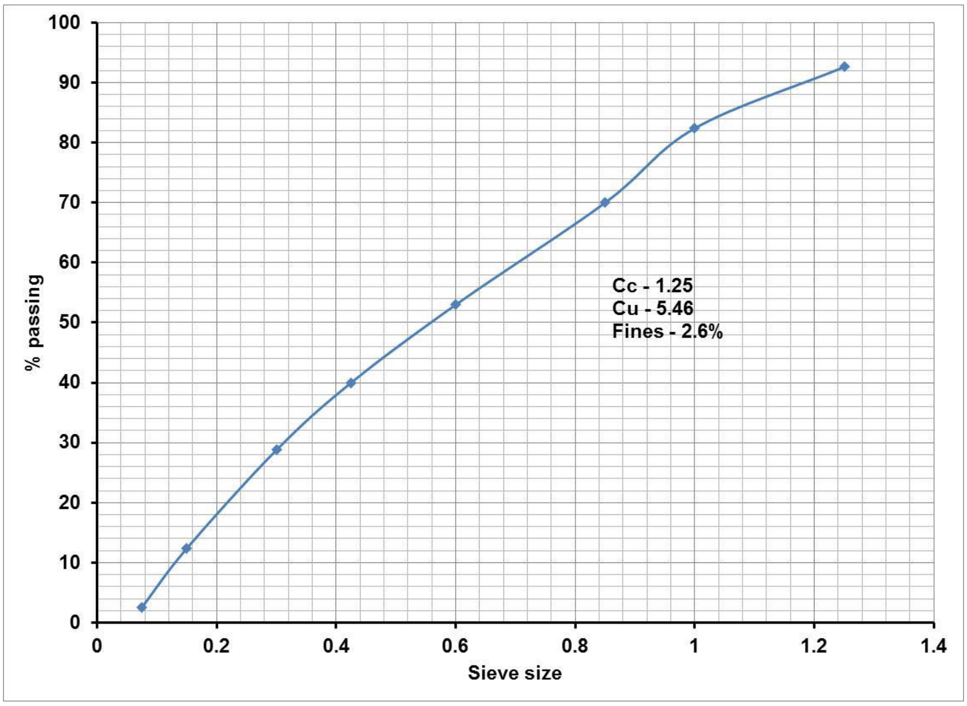

Figure 2. *A plot of sieve analysis.*

Concrete Slump

The result of the concrete slump is shown in Figure 3. Figure 3 revealed that the slump value of the seven concrete sets GS 0, GS 1, GS 2, GS 3, GS 4, GS 5 and GS 6-was 31, 38, 35, 30, 42, 45 and 51 mm, respectively. It can be observed from the slump result that the SBA and cassava starch tend to enhance the concrete's workability, which is comparable to the observations made by Memon *et al.* (2022). Likewise, this research finding depicted that the rice husk tends to retard the workability of the concrete. It was detected that the slump increased from 31-38 mm as the SBA and RH amount inclined from 0-5%, before it started to decline from 38-30 mm as the SBA and RH volume increased from 5-15%. This is an indication that a larger volume of RH hinders the workability of the concrete, which can be attributed to the textural characteristic (roughness) and high-water affinity of the rice husk. The roughness of the RH can interfere with the flow rate of the fresh concrete mixture, while the high RH water absorption rate will deprive the concrete of enough water for hydration and lubrication; hence, leading to the formation of concrete with poor workability (Sotiropoulou *et al.*, 2017).

Remarkably, the findings of the study depicted that the concrete's slump values increased in a non-linearly pattern, when the amount of the cassava starch integrated into the concrete increased from 0 to 3% (GC4, GC5 and GC6). This revealed that cassava starch is a potential green concrete workability booster, resulting in the formation of concrete with more uniform and compacted mixture. These results are in conformity with previous research findings as reported by Abalaka (2011) and Joseph and Xavier (2016). Slump is a vital parameter in concrete technology, as it is an indicator for the fresh concrete consistency, workability, and compatibility. This study's findings revealed that starch and SBA are sustainable and environmentally friendly admixtures, which reduce the volume of water needed for the complete chemical reaction of the cement, thereby boosting the concrete mix design efficiency (Eboibi *et al.*, 2022).

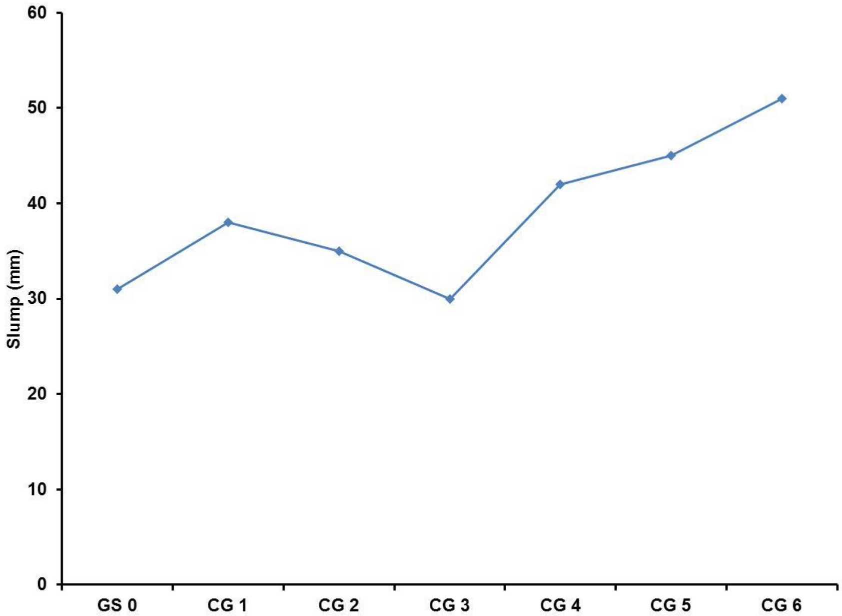

Figure 3. *The results of the concrete units' slump.*

Concrete Density

Figure 4 presents the calculated density of the concrete sets. At the 28th curing day, it was noted that the SBA and the cassava starch had substantial effect on the concrete density. As shown in Figure 4, the density of the control unit (GS 0), GS1, GS2, GS3, GS 4, GS5 and GS6 concrete units was 2470, 2350, 2190, 1970, 2410, 2250 and 2060 kg m^{-3} respectively. This is an indication that the admixture and the rice husk caused a significant reduction in the concrete weight. Memon *et al.* (2022) and França *et al.* (2023) made similar observations during their research into the impact of SBA on the mechanical properties and durability of concrete. The decline in the concrete density can be attributed to the lower specific gravity, porosity and density of the ash when to compared to these parameters' values of the cement (Rattanachu *et al.*, 2018).

Furthermore, the results revealed that the concrete density declined non-linearly as the volume of the rice husk in the concrete increased from 0 to 15% (by weight of the fine aggregates). This finding can be attributed to the lower bulk density of the rice rusk compared to fine aggregate bulk density, therefore increasing the quantity of the materials with lower bulk density in the concrete will translate to reduction in the concrete density (Akpokodje *et al.*, 2019). Additionally, the findings of this research revealed that the density of concrete produced with cassava starch (GC4, GC5 and GC6) as workability enhancer, developed higher density compared to the density of concrete sets produced without cassava starch (GS 1, GC 2 and GC3). This portrayed that cassava starch improves the distribution and dispersion of cementitious materials, leading to a more uniform and densification of the concrete

(Abd *et al.*, 2016; Monteiro *et al.*, 2019). This finding is similar to previous observations of Agbi and Uguru (2021), where cassava starch caused a significant increment in the density of concrete produced with sawdust as a partial replacement for fine aggregates.

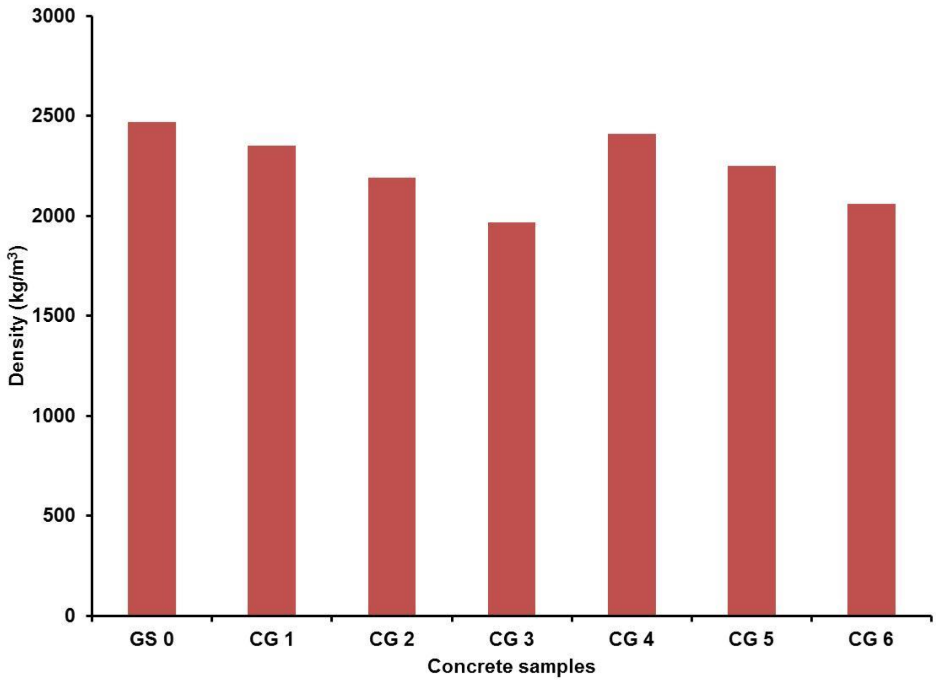

Figure 4. *The impact of admixtures on concrete density.*

Compressive strength

Results gotten for the various concrete units' compressive strength are presented in Figure 5. It can be comprehended from Figure 5 that the compressive strength of the GC0, GC1, GC2, GC3, GC4, GC5 and GC6 concrete units was 21.7, 22, 18.5, 15.4, 22.6, 23.7 and 19.8 N mm^{-2} respectively. It was observed from the results that despite the presence of RH as a partial replacement for fine aggregates, the strength developed by the concrete increased gradually with an increment in SBA volume from 0 to 5%, after which it started to decline as the ash volume increased to 15%; which is similar to the findings made by Memon *et al.* (2022) and Zareei *et al.* (2018) when SBA was used as supplementary cementing material during concrete production.

According to (França *et al.*, 2023) SBA is a prospective pozzolanic material which forms calcium silicate hydrate compound during chemical reaction, thereby contributing to the development of mechanical strengths of the concrete made with it. This trend is a frequent occurrence in green concrete technology. The differences observed in the compressive strength of the concrete experimentally produced in this research, when compared with observations reported by other authors (Zareei *et al.*, 2018; de Siqueira and Coreiro, 2022), can be attributed to the chemical composition of the SBA, particulate size and quality of the SBA employed to create the concrete, and the curing method adopted. Finer admixture particles have the ability of improving composite/concrete strength, when compared to coarse admixture particles, which can be attributed to their increased effective contact surface area, besides reactivity of the fine-grained particles admixture.

Furthermore, findings obtained from this experimental work indicated that the compressive strength of green concrete without cassava starch admixture (GS 1, GC 2, and GS 3) developed lower compressive strength of 19.3, 17.5 and 15.4 N mm^{-2} respectively, compared to green concrete made with different cassava starch content (GS 4, GS 5 and GS 6) that recorded compressive strength of 22.6, 23.7 and 19.8 N mm^{-2} respectively. Interestingly, it was noticed that the cassava starch led to a steady rise in the amount of compressive strength developed as its' amount increased from 0-3%, portraying that cassava starch is a suitable green admixture that has the capacity of augmenting the strength characteristics of concrete. These results are similar to the observations made by Okafor (2010) and Agbi and Uguru (2021), where the compressive strength of cement composite increased non-linearly when the amount of the cassava starch added into the concrete increased linearly.

Effectiveness of cassava starch as concrete mechanical properties enhancer is dependent on the biochemical properties of the cassava starch, the cassava varieties, the concrete mixture design, and the concrete production method (Akindahunsi and Uzoegbo, 2015). According to Akpokodje and Uguru (2019), cassava starch aids the cohesion between the cement matrix and primary aggregates in the fresh concrete, improving the concrete bonding strength in the process, which will lead to higher compressive strength formation at the end of the reaction. Furthermore, these results portrayed that replacing sand with rich husk (at lower volume) can produce concrete with reasonable strength above the 17 N mm^{-2} approved by NIS as minimal allowable compressive strength for concrete meant for residential buildings construction.

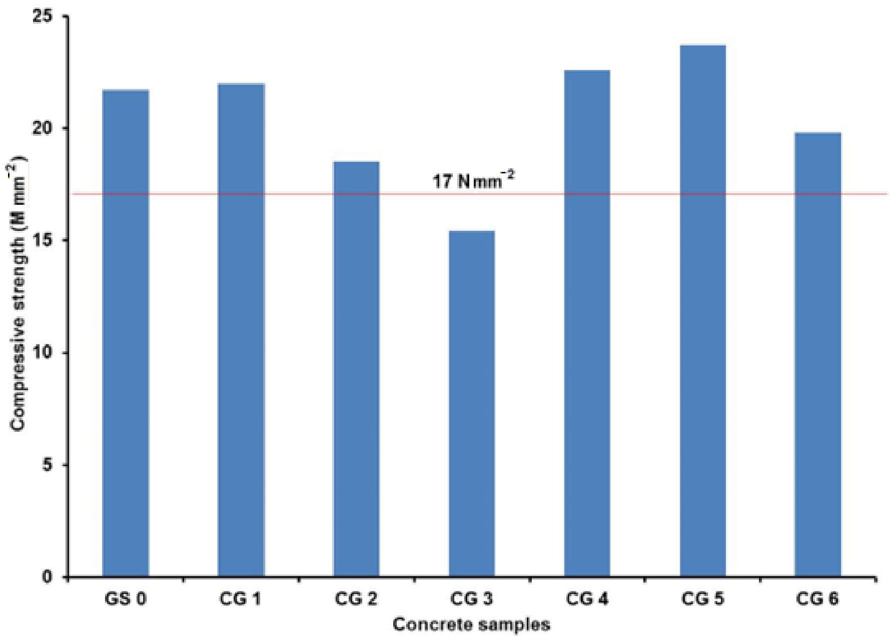

Figure 5. *Compressive strength of the concrete.*

CONCLUSION

This study was done to determine the probability of producing high strength concrete, through the substitution of concrete primary materials-cement and fine aggregates - with organic cementing materials. Six units of modified (green) concrete were produced through the partial replacement of the cement volume with sugarcane bagasse ash (SBA), substituting the fine aggregates content with rice husk (RH), and cassava starch (CS) as organic concrete workability enhancer. Results obtained from the laboratory tests of the concrete indicated that both the SBA and cassava starch have a positive impact on the concrete's engineering properties. The density of the concrete tends to decline in an uneven order, the volume of the SBA (by percentage amount of the cement) and rice husk (by percentage volume of the fine aggregates) increases, which can be attributed to its lower bulk density of the two materials. Likewise, the green concrete's mechanical (compressive) strength inclines with an increment in the percentage of SBA and cassava starch incorporated into the concrete. The maximum compressive strength (23.7 N mm^{-2}) was recorded with substitution of 10% SBA, 10% rice rusk and 2% cassava starch. It was also noted from the observations that both the SBA and CS admixtures enhance the workability of the concrete produced, while the rice husk caused substantial retardation in workability and compressive strength development. Conclusively, this research depicted the substantial potential of SBA, RH and CS hybridization for sustainable high quality concrete production.

DECLARATION OF COMPETING INTEREST

The authors declare that they have no conflict of interest

CREDIT AUTHORSHIP CONTRIBUTION STATEMENT

The authors declared that the following contributions are correct.
Otaghogho Zion Tachere: Designed the research Methodology and writing of the original draft.
Onyekachukwu Nicklette Akpenyi-Aboh: Edited the manuscript.
Ovie Isaac Akpokodje: Data analysis and review of the original draft.
Oderhowho Nyorere: Designed the research and writing the original draft.

ETHICS COMMITTEE DECISION

This article does not require any ethical committee decision.

REFERENCES

Abalaka AE (2011). Comparative effects of cassava starch and simple sugar in cement mortar and concrete. *ATBU Journal of Environmental Technology, 4(1): 13-22.*

Abd SM, Hamood QY, Khamees AS and Ali ZH (2016). Effect of using corn starch as concrete admixture. *International Journal of Engineering Research and Science and Technology, 5(3): 35-44.*

Agbi GG and Uguru H (2021). Assessing the impact of cassava starch on the structural properties of sandcete blocks produced from recycled paper. *Saudi Journal of Engineering and Technology*, *6(5): 99-103.*

Akpokodje OI and Uguru H (2019). Effect of fermented cassava waste water as admixture on some physic-mechanical properties of solid sandcrete blocks. *International Journal of Engineering Trends and Technology*, *67(10): 216-222.*

Akpokodje OI, Uguru H and Esegbuyota D (2019). Study of flexural strength and flexural modulus of reinforced concrete beams with raffia palm fibers. *Journal of Civil Engineering and Construction Technology*, *3(1): 57-64.*

Akpokodje OI, Agbi GG, Uguru H and Nyorere O (2021). Evaluation of the compressive strength of commercial sandcrete blocks produced in two metropolises of Delta State, Nigeria. *Applied Journal of Physical Science, 3(2): 61-71.*

Akindahunsi AA and Uzoegbo H (2015). Strength and durability properties of concrete with starch admixture. *International Journal of Concrete Structures and Materials, 9(3): 323-335.*

Akram T, Memon SA and Obaid H (2009). Production of low cost self compacting concrete using Bagasse Ash. *Construction and Building Materials, 23: 703-712.*

Amalraj EFP and Ilangovan P (2023). Experimental behavior of high-strength concrete reinforced with aramid fiber and polyurethane resin. *Buildings, 13(7): 1713-1725.*

Anjos MAS, Araújo TR, Ferreira RLS, Farias EC and Martinelli AE (2020). Properties of self-leveling mortars incorporating a high-volume of sugar cane bagasse ash as partial Portland cement replacement. *Journal of Building Engineering, 32: 101694-101711.*

ASTM C136 (2006). Standard test method for sieve analysis of fine and coarse aggregates. Retrieved from https://www.astm.org/standards/c136

ASTM C39/C39M (2014). Standard test method for compressive strength of cylindrical concrete specimens. Retrieved from https://www.astm.org/c0039_c0039m-14.html

ASTM C143 (2017) Standard test method for slump of Portland cement concrete. Retrieved from https://www.astm.org/standards/c143

ASTM C642 (2021). Standard test method for density, absorption, and voids in hardened concrete. Retrieved from https://www.astm.org/c0642-21.html.

Chusilp N, Jaturapitakkul C and Kiattikomol K (2009). Utilization of bagasse ash as a pozzolanic material in concrete. *Construction and Building Materials, 23: 3352-3358.*

de Siqueira AA and Cordeiro GC (2022). Sustainable Cements Containing Sugarcane Bagasse Ash and Limestone: Effects on Compressive Strength and Acid Attack of Mortar. *Sustainability*, *14(9): 5683-1597.*

Eboibi O, Akpokodje OI and Uguru H (2022). Evaluation of organic enhancer on the mechanical properties of periwinkle shells concrete. *Journal of Engineering Innovations and Applications, 1(1): 13-22.*

França S, Sousa LN, Saraiva SLC, Ferreira MCNF, Silva MV de MS, Gomes RC, Rodrigues C de S, Aguilar MTP and Bezerra AC da S (2023). Feasibility of Using Sugar Cane Bagasse Ash in Partial Replacement of Portland Cement Clinker. *Buildings*, *13(4): 843-864.*

Joseph SK and Xavier AS (2016). Effect of starch admixtures on fresh and hardened properties of concrete. *International Journal of Scientific Engineering and Research*, *4(3): 27-30.*

Lee H, Hanif, A, Usman M, Sim J and Oh H (2018). Performance evaluation of concrete incorporating glass powder and glass sludge wastes as supplementary cementing material. *Journal of Cleaner Production*, *170: 683-693.*

Memon SA, Javed U, Shah MI and Hanif A (2022). Use of processed sugarcane bagasse ash in concrete as partial replacement of cement: mechanical and durability properties. *Buildings*, *12(10): 1769-1784.*

Monteiro S, Martins J, Magalhães FD and Carvalho L (2019). Low density wood particleboards bonded with starch foam-study of production process conditions. *Materials*, *12(12): 1975-1991.*

Niaki MH, Ahangari MG and Fereidoon A (2022). Mechanical properties of reinforced polymer concrete with three types of resin systems. *Proceedings of Institution of Civil Engineers: Construction Materials, 1-9.*

Nishant R, Abhishek T and Alok KS (2016). High performance concrete and its applications in the field of civil engineering construction. *International Journal of Current Engineering and Technology, 6(3):982-987.*

Okafor FO (2010). The performance of cassava flour as a water-reducing admixture for concrete. *Nigerian Journal of Technology*, *29 (2): 106-112.*

Rattanachu P, Karntong I, Tangchirapat W, Jaturapitakkul C and Chindaprasirt P (2018). Influence of bagasse ash and recycled concrete aggregate on hardened properties of high-strength concrete. *Construction Materials*, *68: 158-172.*

Saleh HM, Salman AA, Faheim AA, El-Sayed AM (2020). Sustainable composite of improved lightweight concrete from cement kiln dust with grated poly (styrene). *Journal of Cleaner Production*, *277: 123491-123505.*

Salem MAA and Pandey RK (2017). Effect of cement-water ratio on compressive strength and density of concrete. *International Journal of Advances in Mechanical and Civil Engineering (IJAMCE), 4(6): 75-77.*

Shafiq N, Hussein AAE, Nuruddin MF and Al Mattarneh H (2018). Effects of sugarcane bagasse ash on the properties of concrete. Proceedings of the Institution of Civil Engineers: *Engineering Sustainability*. *171: 123-132.*

Sotiropoulou A, Gavela S, Nikoloutsopoulos N, Passa D and Papadakos G (2017). Experimental study of wood shaving addition in mortar and statistical modeling on selected effects. *Journal of the Mechanical Behavior of Materials*, *26(1-2): 55-63.*

Suhad MA, Qasssim YH, Alaa SK and Zainab HA (2016). Effect of using corn starch as concrete admixture. *International Journal Engineering Research and Science & Technology*, *5(3): 35-44.*

Uguru H, Akpokodje OI and Agbi GG (2022). Assessment of compressive strength variations of concrete poured in-site of residential buildings in Isoko District, Delta State, Nigeria. *Turkish Journal of Agricultural Engineering Research (TURKAGER*), *3(2), 311-327.*

USCS (2015). Unified Soil Classification System–Soil classification basics. Available online at: http://faculty.uml.edu/ehajduk/Teaching/14.330/documents/14.330SoilClassification.pdf

Usman ND, Chom HA, Salisu C, Abubakar HO and Gyang JB (2016). The impact of sugar on setting - time of ordinary portland cement (OPC) paste and compressive strength of concrete. *Journal of the Environment*, *10(1): 107-114.*

Xu Q, Ji T, Gao SJ, Yang Z and Wu N (2018). Characteristics and applications of sugar cane bagasse ash waste in cementitious materials. *Materials*, *12: 39-48.*

Zareei SA, Ameri F and Bahrami N (2018). Microstructure, strength, and durability of eco-friendly concretes containing sugarcane bagasse ash. *Construction and Building Materials, 184: 258-268.*