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COMPARATIVE STRENGTH ANALYSIS OF CONCRETE USING HIGH ALUMINA CEMENT AND PORTLAND LIMESTONE CEMENT

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Abstract —This study investigates and compares the strength characteristics of concrete incorporating High Alumina Cement (HAC) and Portland Limestone Cement (PLC). Both chemical and physical tests were performed on HAC and PLC, along with additional physical tests to assess aggregate properties. Preliminary testing was conducted in accordance with relevant standards, yielding satisfactory results. Slump tests indicated that the workability of both HAC and PLC concretes fell within the S1 classification. A comprehensive evaluation of compressive, split tensile, and flexural strength was conducted on concrete specimens cured for 3, 7, 14, 21, 28, and 56 days. The results demonstrated that HAC concrete significantly outperformed PLC concrete, with average strength increases of 38% in compressive strength, 15% in split tensile strength, and 21% in flexural strength. Additionally, HAC concrete exhibited 4% lower water permeability than PLC concrete, indicating greater durability. These findings suggest that HAC is a superior option for structural applications requiring rapid strength gain and reduced permeability. Therefore, HAC is recommended for construction applications requiring early load-bearing capacity and improved durability.

***Keywords*:** high alumina cement, portland limestone cement, compressive strength, flexural strength, split tensile strength

1.0 INTRODUCTION

The characteristics of cement depend on its chemical composition and particle intensity, which influence its surface area. Different types of cement are produced by modifying raw material compositions. High Alumina Cement (HAC), for instance, has a distinctly different chemical composition from Portland Limestone Cement (PLC). It primarily consists of calcium and aluminates and is often referred to as aluminous cement. The primary reactive component of Calcium Aluminous Cement (CAC) is monocalcium aluminate ($CaAl_2O_4$, $CaO\cdot Al_2O_3$, CA) [1]. HAC is typically produced using limestone and bauxite [2]. In some cases, HAC is produced using saturated bauxite, lime, and laterite [3, 4]. Lower-quality HAC results from increased silica content, typically 6–8% by weight, and moderate iron incorporation. However, impurities such as titanium, magnesium, and alkali oxides reduce HAC quality by forming undesirable phases. Raw materials may also contain small amounts of crystalline compounds. The production of aluminous cement varies depending on the desired properties and manufacturing process. Production methods include full melting of raw materials or solid-state reactions [5–7]. According to [8], the manufacturing process of high-quality HAC involves combining high-purity raw materials, such as alumina and lime, which are ground and heated simultaneously in a rotary kiln. The reaction primarily produces calcium aluminate (CA) and monocalcium aluminate (CA_2). The presence of impurities, particularly ferric oxide (Fe_2O_3), titanium dioxide (TiO_2), and silicon dioxide (SiO_2), significantly affects the quantity and composition of these phases. These impurities react with alumina and calcium, forming non-hydratable compounds such as alumino-silicates, calcium titanate, and alumino-ferrites. As a result, the amount of calcium aluminate available for hydration decreases, affecting both setting time and strength development [8]. Previous studies have examined various HAC production methods and their impact on refractory performance, emphasizing the role of raw material purity in calcium aluminate phase formation. Shrimali [9] studied the formation stages of HAC under various manufacturing conditions and their impact on refractory castables, focusing on calcium aluminate phases (CA and C_5A_3) and associated minerals such as C_6A_4.FeO.S, C_6A_4MgO.S, and C_2S. The experiment varied production parameters—raw material composition, material ratio, and temperature—and analyzed the mineral composition of the resulting HAC. The HAC samples underwent extensive chemical and mineralogical characterization. The study identified three key findings: (1) aluminum content influences calcium aluminate phase formation, (2) raw material selection impacts HAC configuration stages, and (3) higher purity and reactivity enhance the development of larger alumina phases. Similarly, Lukose [10] conducted a comparative characterization of HAC, Portland Limestone Cement (PLC), and expansive cement, analyzing their distinct properties based on raw material composition. The study examined how cement and concrete properties change with the addition of various additives. The findings indicated that supplementary cementitious materials, such as silica, slag, calcined clay, and kaolinite, influence the cement hydration process. However, the study did not assess these cements in structural concrete applications. Thus, further research is needed to evaluate the structural performance of these cements in concrete applications. According to Talabér [11], notable differences exist in the setting time and strength characteristics between HAC and PLC. The hydration process of HAC concrete is affected by multiple factors. The study emphasized that reducing porosity improves the durability of HAC. Furthermore, lowering alkali content in HAC enhances its suitability for general construction. However, the study examined only the hydration properties of PLC and HAC and did not assess their structural performance in concrete applications. Meanwhile, Mode [12] evaluated Portland Limestone Cement (PLC) manufactured in Nigeria. The study tested four Nigerian PLC brands—Ashaka, Bua, Sokoto, and Dangote—to evaluate their mechanical and durability properties in concrete. Compressive strength tests were performed on concrete samples at 7, 14, and 28 days, along with a water absorption test at 28 days. Dangote PLC achieved the highest compressive strength (29.14 N/mm² at 28 days) and had a water absorption rate of 6.1%. The study excluded HAC and did not assess split tensile or flexural strength. Additionally, the study did not extend concrete curing beyond 28 days. Furthermore, Fapohunda [13] investigated the quotient of split tensile to compressive strength in concrete made with grade 32.5R and 42.5R PLC. These strengths were examined at 7, 14, 21, 28, 60, and 90 days. The results indicated that the quotient of split tensile to compressive strength was higher in concrete made with grade 32.5R PLC compared to grade 42.5R PLC at both early and later curing stages. The study focused exclusively on PLC, excluding assessments of concrete's flexural strength and water absorption. HAC was not included in the experiments. Although these cements have been examined in previous research, this study seeks to expand the understanding by comparing the strength properties of HAC and PLC. Given this context, this study uniquely contributes by directly comparing the strength properties of HAC and PLC, filling an important gap in understanding how these cements perform in structural concrete. The comprehensive testing of compressive, tensile, and flexural strengths further emphasizes the value of this study. The distinctiveness of this research is evident and significant.

2.0 MATERIALS AND METHODS

2.1. Materials

The materials used in this study included HAC, PLC, coarse aggregates (25 mm–2.36 mm), fine aggregates (2.36 mm–75 µm), and water. The HAC was Dangote cement, sourced from Dangote Cement Factory in Ogun State. The PLC used in this study was also Dangote cement (grade 42.5), obtained from the open market in Samaru. The aggregates were collected from a quarry site along Zaria-Funtua Road. Water conforming to [14] standards was used for concrete production.

2.2. Methods

Tests on Cement include the following;

- i Chemical test such was done on the cement in accordance with [15]
- ii Consistency of cement pastes was carried out in accordance with [16]
- iii Setting time of cement pastes carried out as described in [15]
- iv Soundness of cement pastes was conducted as described in [16]

Tests on Aggregate include the following;

- i Specific gravity of cement was carried out in accordance with [17]
- ii Particle size distribution of aggregate was carried out on aggregate in accordance with [18]
- iii Specific gravity aggregate of fine aggregate was conducted in accordance with [19]
- iv Moisture content of aggregate was conducted on the fine aggregate in accordance with [20]
- v Aggregate Impact Value was conducted in accordance with [21]
- vi Aggregate Crushing Value test was done as described in [22]

Tests on Concrete include the following;

- i Slump Test was done as described in [23]
- ii Compressive Strength Test cubes was done in accordance to [24]
- iii Split Tensile Strength was done as described in [25]
- iv Flexural Strength Test was conducted as described in [26]
- v Water Absorption of Concrete was conducted as described in [27]

2.3. Concrete Mix Design

The procedure for job mix as prescribed by Council for Regulation of Engineering in Nigeria [28] was adopted for selection and proportion of different materials utilized for this study. The concrete was designed to be sufficient for strength and slump for concrete grade 20 (C20/25). Table 1 shows the detailed mix proportion of concrete.

Table 1 Concrete Mix Design and Proportion

MIX DESIGN FOR GRADE 42.5 CEMENT

S/NO	ITEM	UNITS	
1	**STAGE 1**		
1.1	Characteristic Strength	N/mm^2	20
1.2	Standard Deviation	N/mm^2	5
1.3	Margin	N/mm^2	6
1.4	Target Mean Strength	N/mm^2	31
1.5	Cement Grade		42.5
1.6	Aggregate Type: Coarse		Crushed
1.7	Aggregate Type: Fine		Uncrushed
1.8	Free Water/Cement Ratio		0.5
1.9	Maximum Free Water/Cement Ratio		NONE
2	**STAGE 2**		
2.1	Slump	mm	30 - 60
2.2	Maximum aggregate size	mm	20
2.3	Free-Water Content	kg/m^3	210
3	STAGE 3		
3.1	Cement Content	kg/m^3	420
3.2	Maximum Cement Content	kg/m^3	NONE
3.3	Minimum Cement Content	kg/m^3	NONE
3.4	Modified Free-Water/Cement Ratio		NONE
4	**STAGE 4**		
4.1	Concrete Density	kg/m^3	2400
4.2	Total Aggregate Content	kg/m^3	1700
5	**STAGE 5**		
5.1	Grading of Fine Aggregate		
5.2	Proportion of Fine Aggregate		
5.3	Fine Aggregate Content	kg/m^3	
5.4	Coarse Aggregate Content	kg/m^3	
6	**STAGE 6 – Trial Mix Quantities**		150mm Cube
6.1	Water	kg/m^3	210
6.2	Cement	kg/m^3	420
6.3	Fine Aggregate	kg/m^3	620
6.4	Coarse Aggregate	kg/m^3	1150

2.4. Preparation and Production of Concrete Specimens

This study involves the production of concrete and the examination of its strength characteristics using PLC and HAC. The concrete mix design yielded a mix ratio of 1:1.47:2.74 with a water/cement ratio of 0.5. The concrete is classified as strength class C20/25.

Three samples were produced for compressive, split tensile, and flexural strength testing using PLC and HAC at 3, 7, 14, 21, 28, and 56 days. For the compressive strength test, 150 × 150 × 150 mm molds were used, resulting in 36 cubes (3 samples per time period for each cement type). For the split tensile strength test, 150 × 300 mm cylindrical molds were used, producing 36 samples. For the flexural strength test, 150 × 150 × 600 mm molds were used, also producing 36 samples.

The quantities of the concrete's constituent materials were calculated using the weight method, and hand mixing was employed. The molds were carefully assembled and greased before mixing to facilitate easy demolding. The specimens were prepared in accordance with relevant standards [24] and were demolded after 24 hours. Preparation took place in the concrete laboratory at the Department of Civil Engineering, Ahmadu Bello University, Zaria, Nigeria. Water tank curing was chosen to promote strength development, with curing periods of 3, 7, 14, 21, 28, and 56 days in clean water. The concrete samples were weighed, and their densities were measured at different testing times. All tests, including slump, compressive strength, split tensile strength, water absorption, and flexural strength, were carried out in accordance with the specified standards [23–27].

3.0 RESULTS AND DISCUSSION

3.1. Chemical Composition of PLC and HAC

The chemical composition test results are presented in Table 2. For HAC, the detected values were as follows: sodium oxide (Na_2O) at 0.06%, magnesium oxide (MgO) not detected, alumina oxide (Al_2O_3) at 55%, silicon oxide (SiO_2) at 15.75%, phosphorus pentoxide (P_2O_5) at 0.69%, sulfur trioxide (SO_3) not detected, potassium oxide (K_2O) at 0.03%, calcium oxide (CaO) at 10.32%, titanium dioxide (TiO_2) at 2.31%, iron oxide (Fe_2O_3) at 12.46%, and barium oxide (BaO) at 0.94%. Loss on Ignition (LOI) was not detected. The chemical composition of HAC met the specifications of BS EN 14647 [29]. The sum of alkalis ($Na_2O + 0.658K_2O$) in HAC amounted to 0.09%, reducing the probability of a destructive alkali-aggregate reaction, which can cause concrete disintegration. This also satisfies the requirements of [29]. SO_3 and sulfide (S^{2-}) were not detected, remaining within the limits specified by BS EN 14647 [29].

For PLC, the results were as follows: calcium oxide (CaO) at 64.45%, silicon oxide (SiO_2) at 21.55%, alumina oxide (Al_2O_3) at 5.28%, iron oxide (Fe_2O_3) at 3.95%, magnesium oxide (MgO) at 1.85%, sulfur trioxide (SO_3) at 1.50%, Loss on Ignition (LOI) at 1.44%, and insoluble residue at 0.65%. The chemical composition of PLC complies with BS EN 196-2 [15] specifications. The results indicate that both HAC and PLC are suitable for producing durable and sound concrete. Similar findings were reported by Ayoyemi et al., Kabilis et al., and Abolhasani et al. [30–32].

Table 2 Chemical Composition of HAC and PLC

HAC Chemical	% Composition	BS EN 14647 (2005)	PLC Chemical	% Composition	BS EN 196-2 (2013)
Al_2O_3	55.83	35 % ≤ Al_2O_3 ≤ 58 %	CaO	64.45	Not specified
Ba0	0.14	Not specified	Al_2O_3	5.28	Max. 6.3%
CaO	10.32	Not specified	Fe_2O_3	3.95	Max. 6.5%
Fe_2O_3	12.46	Not specified	MgO	1.85	Max. 4.0%
K_2O	0.03	≤ 0,4 %	SiO_2	21.55	Max. 35.5%
MgO	0.56	Not specified	SO_3	1.5	Max. 3.0%
Mn_30_4	0.94	Not specified	LOI	1.44	Max. 5.0%
Na_2O	0.06	≤ 0,4 %	Insoluble residue	0.65	Max. 1.5%
P_2O_5	1.6	Not specified			
SiO_2	15.75	Not specified			
TiO_2	2.31	Not specified			
SO_3	-	≤ 0,5 %			
LOI	NIL	Not specified			

3.2. Physical Properties of HAC and PLC

The results of the average of three experimental tests on the physical properties of HAC and PLC are shown in Table 3. The tests conducted included specific gravity, consistency, soundness, and initial/final setting times. HAC exhibited distinct values compared to PLC, which can be attributed to its main compounds, such as calcium aluminate (CA and C_5A_3), and other compounds present, including $C_6A_4.FeO.S$ and $C_6A_4MgO.S$ in an isomorphous state, as well as C_2S. HAC's calcium aluminate phases accelerate setting and strength gain, while compounds like C_2S and isomorphous phases ($C_6A_4.FeO.S$, $C_6A_4MgO.S$) contribute to soundness and help temper the rapid setting effects, ensuring a balance between workability and durability. These findings suggest that the properties of both cements are adequate for concrete production. Similar results were reported by [33, 34].

Table 3 Physical Properties of the High Alumina Cement

Test Conducted	HAC Results	Code Specification		PLC Results	Code Specification		Remark
		Min	Max		Min	Max	
Specific gravity	3.33	2.6	3.15	3.14	2.6	3.15	Satisfactory
Consistency	29	26	33	26.8	45	600	Satisfactory
Soundness	7	-	10	0.62	-	10	Satisfactory
Initial and final setting time (mm)	145/230	90	-	92/150	26	33	Satisfactory

3.3. Particle Size Distribution of Aggregate

The results of aggregate gradation for fine and coarse aggregates are presented in Figures 1 and 2, respectively. The fine aggregate is classified as Zone 2, as its gradation falls within the envelope specified by [35]. However, [35] does not provide a gradation envelope for coarse aggregate. Tables 4 and 5 present the particle size distribution for fine and coarse aggregates, respectively. The sieve analysis results indicate that the aggregates are well-graded, which helps reduce pores in the concrete and improves cement binding capacity. Therefore, both fine and coarse aggregates are considered suitable for concrete production.

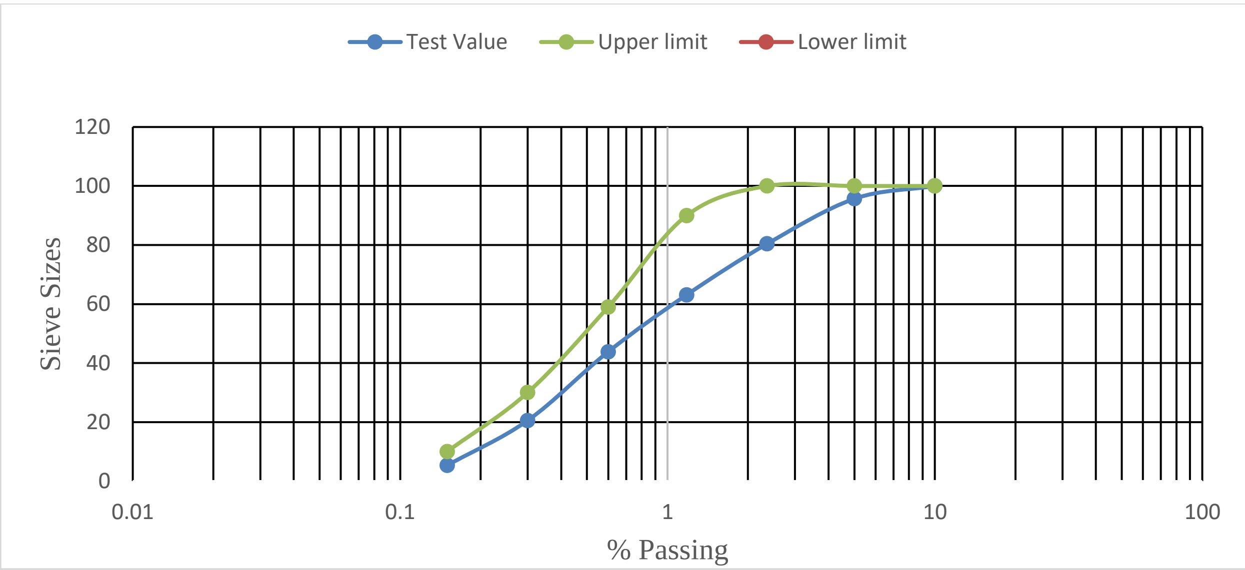

Figure 1 Sieve analysis of fine aggregate

Table 4 Particle size distribution of fine aggregate

Sieve size	Weight retained (g)	Cumulative weight retained (g)	% Retained	Cumulative percentage Retained %	% passing	BS EN 1260 (2008) Zone 2 % passing
4.76	9.8	9.8	0.98	0.98	100	90-100
3.65mm	53.5	63.3	5.35	6.33	93.67	75-100
1.18mm	202.5	265.8	20.25	26.58	73.42	55-90
600µm	303	568.8	30.3	56.88	43.12	35-59
300µm	293	861.8	29.3	86.18	13.82	8-30
150µm	123	984.8	12.3	98.48	1.52	0-10
75µm	12	996.8	1.2	99.68	0.32	-
Pan	3	999.8	0.3	99.98	0.02	-

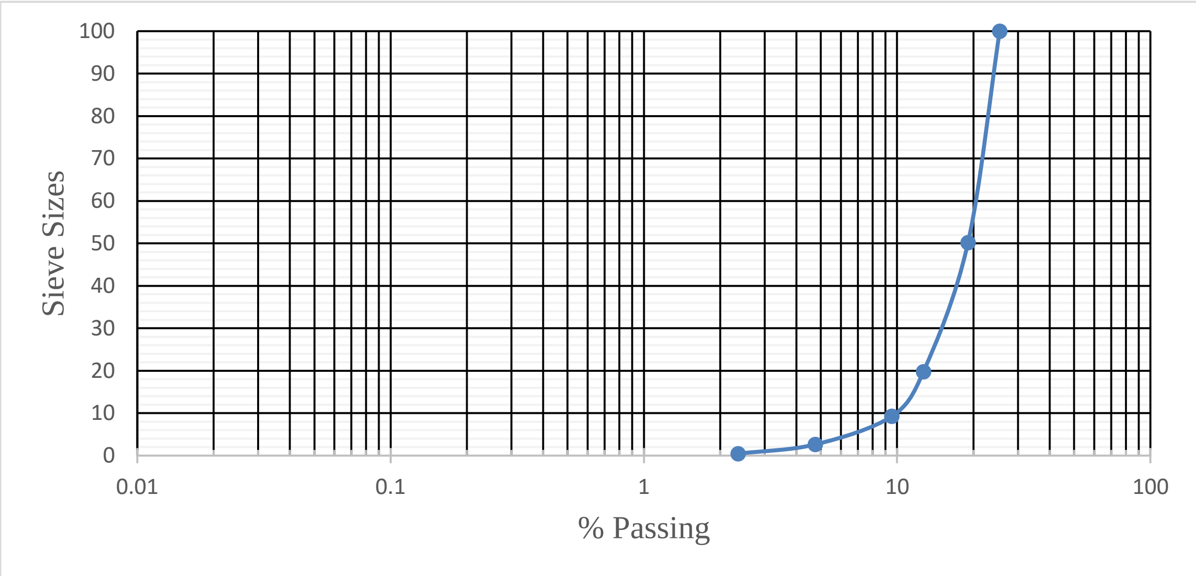

Figure 2 Sieve analysis of coarse aggregate

Table 5 Particle size distribution of coarse aggregate

Sieve size (mm)	Weight retained (g)	Cumulative weight retained (g)	% Retained	Cumulative percentage Retained %	% passing
25.4	0	**0**	**0**	**0**	100
19.05	498.2	498.2	49.82	49.82	50.18
12.7	304.32	802.52	30.43	80.25	19.75
9.52	104.95	907.47	10.50	90.75	9.25
4.76	66.1	973.57	6.61	97.36	2.64
2.36	21.83	995.4	2.183	99.54	0.46
Pan	4.6	1000	0.46	100	0.00

3.4. Physical Properties Test on Aggregates

The results of the physical property tests on fine and coarse aggregates, compared with code specifications, are presented in Table 6. The tests included silt content, specific gravity, impact value, flakiness and elongation indices, crushing value, and moisture content, all conducted in accordance with relevant standards. Table 6 shows that the aggregates meet code specifications for toughness, strength, and density, making them suitable for concrete production. Similar findings were reported by [36].

Table 6 Physical Properties of the Fine and Coarse Aggregate

Test Conducted	ASTM/BS Code	Test Results	Code Specification		Remark
			Min	Max	
Specific gravity	BS 812-2 (1995)	2.63	2.4	3.0	Satisfactory
Silt content (%)	ASTM C117 (1995)	3.98	-	8	Satisfactory
Impact Value (%)	BS 812 112, (1990)	25.4	-	30	Satisfactory
Flakiness Index	ASTM D4791 (2019)	18.7	-	25	Satisfactory
Elongation Index	ASTM D4791 (2019)	20.1	-	25	Satisfactory
Crushing Value (%)	BS 812-110 (1990)	23.3	-	30	Satisfactory
Moisture Content (%)	BS EN 1097-6 (2022)	8.5	-	15	Satisfactory

3.5. Slump of Fresh Concrete Produced with PLC and HAC

The results of the concrete slump produced with PLC and HAC are presented in Figure 3. Slump values measure the consistency or workability of a concrete batch. Both PLC and HAC concrete slumps fall within the S1 classification—that is, slump values within the range of 10–40 mm, according to [23]—indicating uniformity within the batch mixes. Notably, HAC concrete exhibited higher slump values than PLC concrete, which can be attributed to HAC's greater surface area [37]. Nevertheless, the slump values for both types of cement remain within the acceptable limits specified by [23, 38].

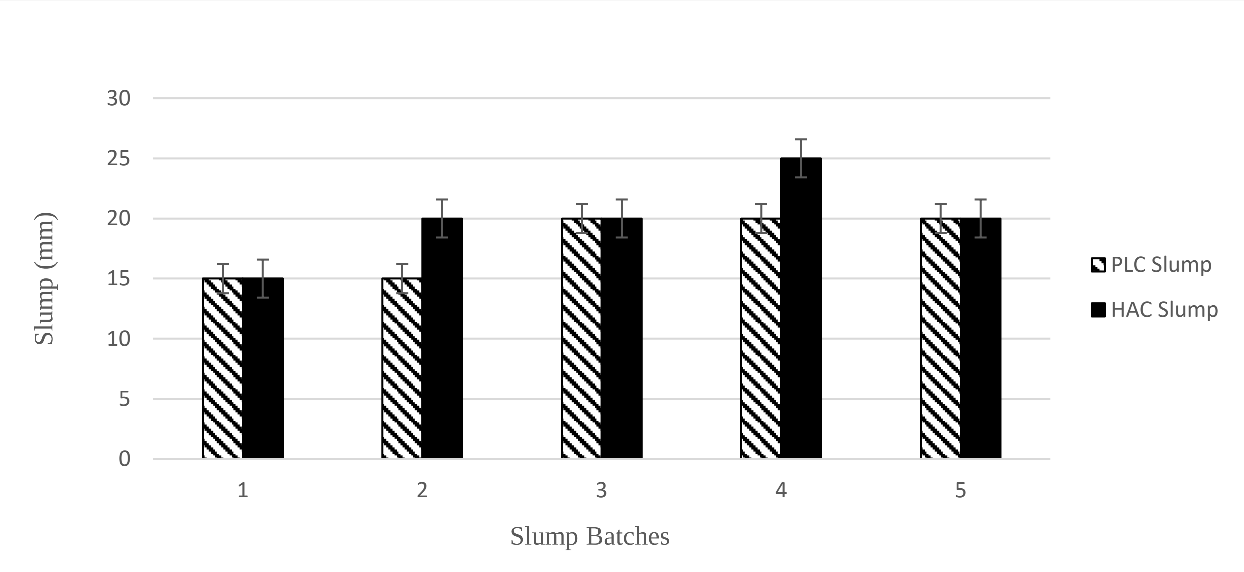

Figure 3 Slump for PLC and HAC concrete

3.6. Compressive Strength of Concrete Produced with PLC and HAC

The compressive strength of concrete produced with PLC and HAC is shown in Figure 4. The compressive strength of PLC at 3, 7, 14, 21, 28, and 56 days was 10.37, 17.41, 19.56, 22.22, 24.15, and 24.89 N/mm², respectively. As the age increased, the compressive strength also increased, showing an average strength gain of 38% from day 3 to day 56. This increase is related to the hydration of Calcium Silicate Hydrates (C-S-H). According to [37], the tricalcium silicate (C_3S) compound in PLC is responsible for early hydration, while dicalcium silicate (C_2S) plays a role in later-stage strength development. Thomas and Jennings [39] stated that continuous curing enhances hydration, leading to the formation of successive C-S-H sheets, making the concrete stiffer, stronger, and denser. The 28-day strength of 24.16 N/mm² meets the recommendation by [40], which stipulates that the compressive strength of normal-weight concrete at 28 days should be between 20 N/mm² and 34 N/mm². For HAC, compressive strength increased with curing time, following the same pattern observed in PLC. The compressive strength at 3, 7, 14, 21, 28, and 56 days was 16.89, 20.89, 24.07, 25.70, 36.30, and 39.11 N/mm², respectively. Higher compressive strength is crucial, as it enables concrete to withstand significant pressure and weight, which is essential for structural stability and durability. Although [29] does not specify limits for HAC compressive strength due to its rapid hardening properties, testing is necessary to observe strength variation over time. When comparing the compressive strength of PLC and HAC concrete, an average strength increase of 38% was observed in HAC across all curing ages. Pratt [41] attributed this increase to the rapid reaction of 43% of HAC within 24 hours, whereas other cement types react more slowly. Pratt [41] further stated that 55% of HAC reacts within 7 days and continues to react up to 90 days. The primary compound in HAC responsible for strength development is monocalcium aluminate (CA), which, during hydration, produces calcium aluminate hydrates and insoluble alumina trihydrate without releasing calcium hydroxide [29]. The results show a significant difference in PLC and HAC compressive strength at 28 and 56 days, attributed to higher calcium content in HAC. Additionally, impurities influence strength development at early curing ages (3, 7, 14, and 21 days). Stinnessen et al. [8] suggested that lime and alumina compounds react to form various cement phases during production, predominantly CA (calcium monoaluminate) and CA_2 (calcium dialuminate). Impurities—particularly SiO_2, TiO_2, and Fe_2O_3 (S, T, F)—can significantly impact the amount and ratio of these phases, leading to inconsistencies in cement properties. These impurities preferentially react with calcia and alumina, forming non-hydratable compounds such as calcium titanate, calcium alumino-ferrites, and calcium alumino-silicates, reducing the available calcium aluminate for hydration and affecting setting time and strength development. However, at 28 and 56 days, the effects of these impurities become insignificant.

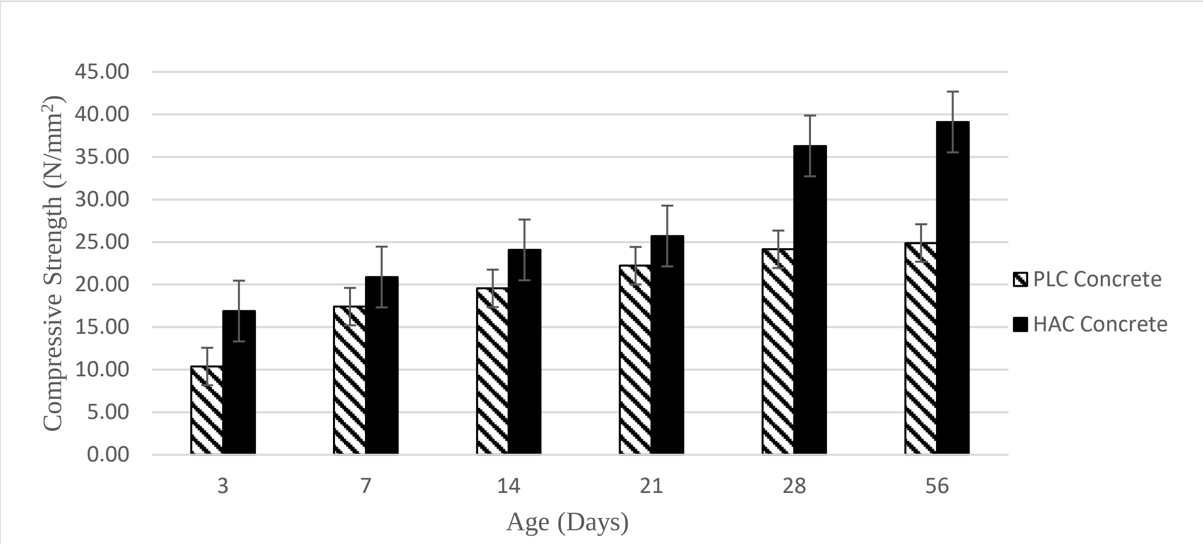

Figure 4 Compressive strength of PLC and HAC concrete

3.7. Split Tensile Strength of Concrete Produced with PLC and HAC

The split tensile strength of concrete containing PLC and HAC was assessed to evaluate their tensile performance. The results are presented in Figure 5. The split tensile strength of PLC at 3, 7, 14, 21, 28, and 56 days was 3.55, 3.78, 3.78, 3.78, 3.61, and 3.59 N/mm², respectively. For HAC, the values at the same intervals were 3.87, 3.96, 4.18, 4.31, 4.30, and 4.59 N/mm². HAC concrete exhibited better split tensile performance than PLC concrete, with an average 15% higher split tensile strength across all curing ages. This superior performance can be attributed to the higher calcium content in HAC, which promotes greater formation of C-S-H sheets. These sheets help fill micro-voids, thereby enhancing split tensile strength. Similar observations regarding tensile strength improvement due to finer particles were noted in [42].

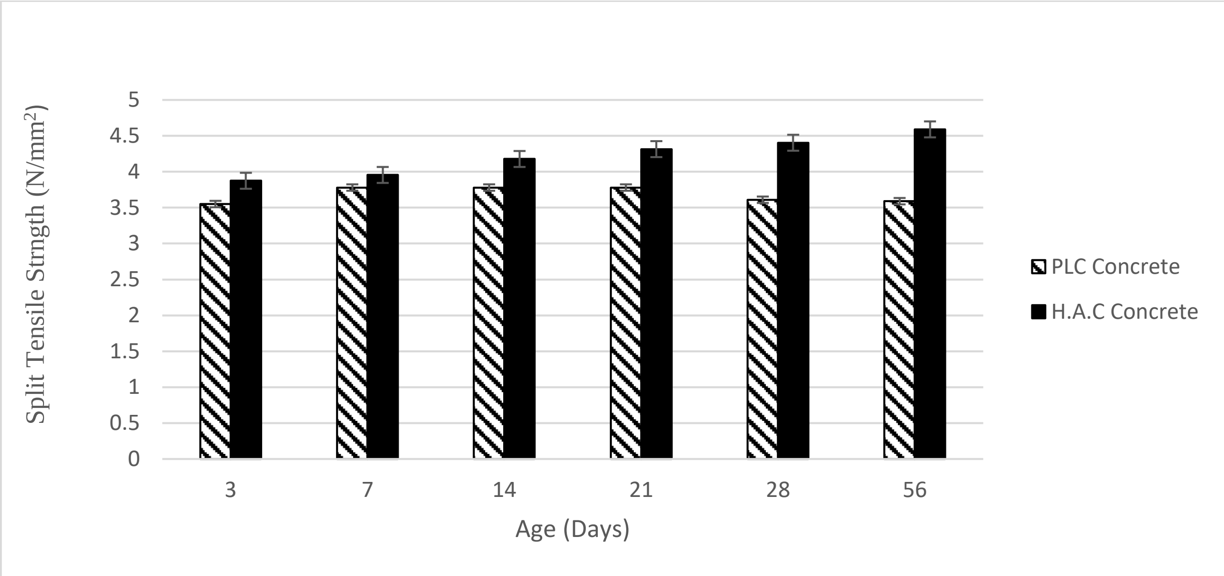

Figure 5 Split strength of PLC and HAC concrete

3.8. Flexural Strength of Concrete Produced Using PLC and HAC

The flexural strength of concrete with PLC and HAC was assessed to evaluate their performance. The results are shown in Figure 6. HAC concrete demonstrated superior flexural strength compared to PLC concrete. The flexural strength of PLC at 3, 7, 14, 21, 28, and 56 days was 6.21, 5.32, 4.56, 3.99, 4.00, and 3.60 N/mm², respectively. For HAC, the values at the same intervals were 7.22, 6.72, 5.19, 5.00, 4.88, and 4.44 N/mm², reflecting performance improvements of 16%, 26%, 14%, 25%, 22%, and 23% at 3, 7, 14, 21, 28, and 56 days, respectively. This higher performance of HAC concrete is attributed to the presence of alkaline substances, which enhance its reactivity. Neville and Brooks [43] observed that lime or alkaline compounds in HAC accelerate the rate of conversion. "Conversion" refers to the transformation process of hydrated monocalcium aluminate (CA), in which CA first forms CAH_{10}, a precursor to both C_2AH_8 and an alumina coagulant ($Al_2O_3 \cdot Aq$). Over time, the hexagonal CAH_{10} crystals transform into cuboid C_3AH_6 crystals, alongside the continued presence of the alumina coagulant.

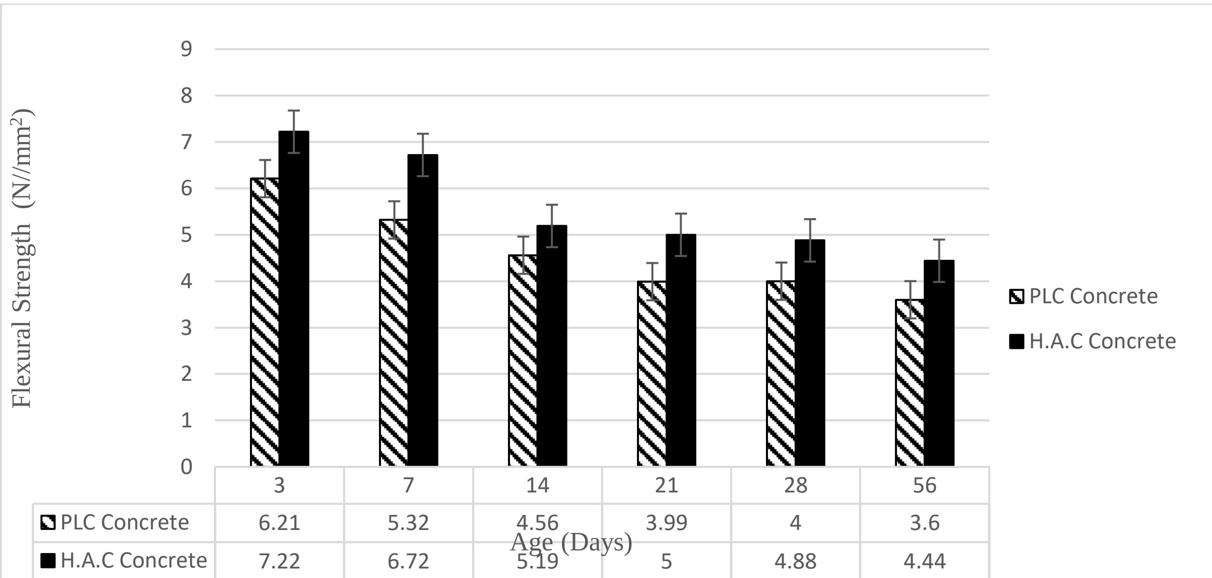

Figure 6 Flexural strength of PLC and HAC

3.9. Water Absorption of Concrete Produced Using PLC and HAC

Water absorption is a key measure of concrete durability, indicating the susceptibility of unsaturated concrete to water ingress. The water absorption test results for PLC and HAC are shown in Figure 7. The data show that HAC concrete exhibited lower water absorption values compared to PLC concrete. The water absorption values for PLC were 2.32, 2.36, 2.47, 2.45, 2.41, and 2.30%, while for HAC, they were 2.11, 2.33, 2.38, 2.40, 2.37, and 2.22%. These results indicate that HAC concrete had an average 4% reduction in water penetration susceptibility compared to PLC concrete. This improved performance can be attributed to HAC's ability to produce gels that enhance pore closure within the mixture. Similar findings were reported by Ghonaim et al. [44], in a related experiment where concrete containing 81% bauxite and grog with 51% alumina was tested for water absorption.

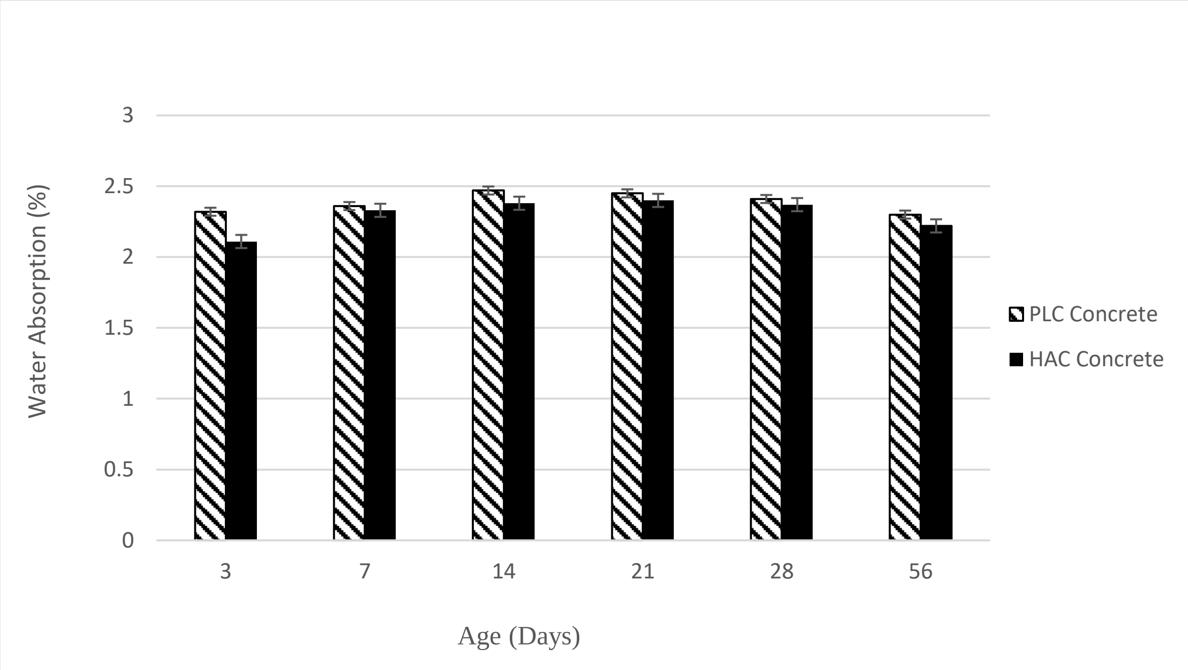

Figure 7 Water absorption of PLC and HAC concrete

4.0 CONCLUSION

HAC and PLC obtained from the Dangote Cement Factory were used in concrete production and cured for 3, 7, 14, 21, 28, and 56 days. The physical and chemical characteristics of both cement and aggregates met the specified standards, confirming their suitability for concrete production. The slump values of the PLC and HAC concretes complied with ASTM and BS standards, falling within the range of 10–40 mm, which is the acceptable limit for the S1 classification.

Furthermore, HAC concrete demonstrated superior compressive, split tensile, and flexural strengths compared to PLC concrete, outperforming it by 38%, 15%, and 21%, respectively. These results suggest that HAC offers enhanced load-bearing capacity, making it suitable for structural applications. Additionally, HAC concrete exhibited a 4% lower water absorption than PLC concrete, which can be attributed to the formation of gel during the curing process. A higher compressive strength is essential to ensure that structures can support heavy loads, withstand environmental factors, and maintain safety throughout their intended lifespan.

Conflicts of Interest

The authors assert that there are no conflicts of interest regarding the publication of this paper.

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