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VARIATIONS IN CONCRETE QUALITY PRODUCED FROM A BLEND OF CLAY-BASED CONCRETE ADMIXTURES AND MULTIPLE ADDITIVES FOR STRUCTURAL APPLICATIONS

ABSTRACT

The present study examines the variation in the quality of concretes (in terms of compressive strength) produced from a blend of clay-based concrete admixtures and multiple additives using standard test methods such as slump test, concrete cube test, curing duration etc. It was observed that for control samples with no clay and high clay content at 7, 14, and 28 days of curing, the average compressive strengths were 21.05, 22.13, 30.62 and 13.57,14.26 21.49N/mm^2. For periwinkle shell ash and superplasticizer (conplastSP430) combined together at 7, 14 and 28 days at 5%, the compressive strength were 26.06, 24.76 and 27.52N/mm^2. Similarly for Rice husk ash and Hydrated Lime combined together at 7, 14, and 28 days at 5%, the compressive strength were 29.47, 29.02 and 31.52N/mm^2. For all additives combined together at 5% and 2.5% each at 7, 14 and 28 days, the compressive strengths were 11.15, 15.52, 20.64 and 18.11, 22.79. 25.68N/mm^2 respectively. However, superplasticizer (conplastSP430) at 10% yielded the highest compressive strength of 30.78, 33.48, and 35.72 at 7, 14, and 28 days curing. This implies that concrete with high clay content possess low compressive strength as well as low quality which is not suitable for structural applications, in which case can be improved to satisfactory levels and percentages when combined with additives at adequate curing durations and mix ratios.

Keywords: Compressive Strength, Concrete, Mix Ratio, Curing Period, Additives

1. INTRODUCTION

Being one of the most ubiquitous material in the world, concrete is a nanostructured, multiphase composite material, with mechanical behaviour that to some extent depend on the structural elements and particles that are effective on a micro and nanoscale [1 and 2]. The properties of concrete is influenced by age, type of material, curing procedure, water cement ratio, size of aggregate, type of aggregate etc. Therefore, in-depth understanding of these parameters is required for optimum concrete strength in structural applications [3]. The size of calcium silicate hydrate (C-S-H) phase, the primary component responsible for strength lies in a few range of nanometers [4]. The structure of C-S-H is much like clay, with thin layers of solids separated by gel pores filled with interlayer and adsorbed water [5]. The application of additives which exist in various forms in different part of Nigerian is more likely to reduce the cost of building construction significantly. On the other hand, the use of these materials have some tendencies to reduce certain problems posed by

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excessive clay content in sand which is the conventional fine aggregate for concrete works in Nigeria [6]. In an experimental study carried out by Ikpe et al. [7], it was observed that clay particle size with percentage fines (particles less than 0.075mm) ≥20% contain high clay content or high silt. In recent times, studies have been conducted on improving the quality and performance of concrete mixtures using different additives.

Samani et al. [8] investigated the effect of fly ash application on concrete, transport properties of high volume fly ash after exposure to high temperature as well as the influence of curing temperature on the strength of fly ash-recycled concrete aggregate blends. The results revealed that the properties of composite containing fly ash depends on the age of the concrete. Results also revealed that transport properties of concrete increased significantly after exposure to 400°C and the results achieved on fly ash-recycled concrete aggregate led to the conclusion that 15% fly ash content is the optimum blend for road stabilization applications. It was found that the preferred solution is to use composite containing 20% coal fly ash (CFA) additive for concrete commissioned after 28 days.

Qadir et al. [9] investigated and quantified the effects of lime on the setting time, consistency, flowability and strength properties of cement mortar. It was observed that the addition of lime to cement mortar decreases the consistency, initial and final setting times of cement mortar by 5%, 27%, and 16%. Addition of 20% lime as a replacement of cement in cement mortar reduced the flow ability by 4%. Based on the experimental data, addition of 20% lime decreased the compressive strength of cement mortar at 1, 3, 7 and 28 days of curing. Addition of 20% of lime reduced the bond strength of cement mortar by 138% at 7 days of curing.

Demyanenko [10] studied the effect of silica additives on the properties of hardened cement paste. Peculiarities of the structural state and phase composition of cement with additives were also studied by derivatographic and X-ray diffraction analysis. The results showed the synergetic effect existing due to joint action of silica additives with different degree of dispersion on 30% increase of cement strength after 28 days of curing compared with the control samples. The patterns also showed synergistic effects of silica additives with different degree of dispersion on the properties of hardened cement paste.

Bamigboye et al. [11] examined different brands of cement to determine the brand with highest compressive strength for engineering structures. Compressive strength at 28 days showed that Dangote 3X cement produced 25.27N/mm^2, Ibeto cement 38.89N/mm^2, Purechem cement 24.58N/mm^2, Unichem cement 21.16N/mm^2 and Elephant cement 27.9N/mm^2 for 1:2:4 mix ratio respectively. For 1:3:6 mix ratio at 28 days, Dangote cement produced 18.89N/mm^2, Ibeto cement 22.07N/mm^2, Purechem cement 11.63N/mm^2, Unichem cement 15.86N/mm^2 and Elephant cement 16.71N/mm^2 respectively. The study concluded that Ibeto cement has the highest strength at 28 days for 1:2:4 and 1:3:6 mix ratios.

Machado et al. [12] conducted an experiment to enhance the compressive strength and setting time of Portland Cement (PC) using one of the following additives: 20% and 30% poly-methylmethacrylate (PMMA), 20% and 30% irregular and spherical amalgam alloys, and 10% $CaCl_2$. The setting time was determined using Gillmore apparatus according to standardized methods while compressive strength was measured using a universal testing machine after 21 hours or 60 days of water storage. All additives significantly reduced the setting time while 30% spherical amalgam alloy yielded a significant increase in compressive strength for the tested PC.

The effect of different additives on the compressive strength of clay-based concrete admixtures was evaluated by Ndon and Ikpe [13] using standard test methods such as slump test, concrete cube test, curing etc. The findings revealed that incorporation of additives in concrete mixture does not have any detrimental effect on the overall performance of the concrete; rather, it helps to improve the strength of the concrete. It was observed that the workability of concrete decreased with increasing percentage of additives in the mixture which resulted in the concrete not being workable enough.

Sathya et al. [14] employed water hyacinth extract as bio-admixture in cement and concrete. Delay was observed in the setting time with increase in replacement percentage of the bio-admixture while compressive strength and workability were observed to increase with increasing concentration of bio-admixture. It was noted that sorptivity decreased with increase in replacement percentage. Bio-admixture was identified as retarding, but strengthening agent of concreate due to the presence of phytochemicals such as lingo-cellulose, saturated and unsaturated fatty acids.

Oyekan and Kamiyo [15] investigated the effects of partial replacement of cement with rice husk ash (RHA) on some engineering properties of hollow sandcrete blocks (225x225x450mm) with 1:6 cement sand mix ratio. As the percentage RHA content in the mixture increased, the compressive strength of the sandcrete block decreased. The density of the blocks decreased as the percentage RHA content in the mixture also increased. The sandcrete block with RHA-blended cement was observed to be more porous than pure sand-cement block. Its permeability increased with RHA content and ambient temperature. As the percentage RHA content increased beyond 20%, the thermal conductivity reduced with increasing RHA content.

Compressive strength tests were carried out by Dabai et al. [16] on six mortar cubes with cement replaced by rice husk ash (RHA) at five levels (0, 10, 20, 30, 40 and 50%). The compressive strengths of the cubes at 10% replacement were 12.60, 14.20, 22.10, 28.50 and 36.30N/mm^2, and increased with age of curing but decreased with increase in RHA content for all mixes. The chemical analysis of the rice husk ash revealed high amount of silica (68.12%), alumina (1.01%) and oxides such as calcium oxide (1.01%) and iron oxide (0.78%) responsible for strength and setting of the concrete. The results also revealed that RHA can be used as cement substitute at 10% and 20% replacement as well as 14 and 28 day curing age.

Attah et al. [17] investigated the effects of sulphuric acid on compressive strength of cement blended with periwinkle shell ash (PSA) concrete. The cement component was replaced with PSA at 0%, 5%, 10%, 15% and 20%, using a mix ratio of 1:2:4 and a constant water cement ratio of 0.6. Results indicated that the compressive strength increased with age and decreased with PSA content for specimen cured in water (control); while for specimen cured in sulphuric acid solutions, the compressive strength decreased with age, PSA content as well as sulphuric acid content.

Abdul-Wahab et al. [18] conducted experiments to determine the optimum proportion of zeolite and zeolite-kaolin as additives in cement clinker and gypsum samples. For all testing ages of zeolite-containing cement mixture, the best compressive strength values were obtained with cement mixture quantities of 88% cement clinker, 5% gypsum, and 7% zeolite. Cement mixture of 70% cement clinker, 5% gypsum, 10% zeolite, and 15% kaolin yielded the best results for zeolite-kaolin-based cement mixture. Cement mixtures obtained with partial replacement of cement clinker with up to 7% zeolite, or 10%

zeolite + 10% kaolin, or 10% zeolite + 15% kaolin provided adequate compressive strength and required less cement clinker.

Awang et al. [19] investigated the effect of additives on mechanical and thermal properties of lightweight foamed concrete (LFC). The low density of LFC produced poor mechanical properties but good thermal properties, as it was influenced by the production of pores. Large size and number of pores cause weak bonding of matrixes thus affect the mechanical properties of LFC at low density. Fly ash as cement replacement contributed to the mechanical properties of LFC. Both compressive and flexural strength increased with longer curing period as slow pozzolanic reaction took place. Fly ash helped in producing small size and uniform distribution of pore. This contributed to the improved strength as each pore and void were well connected.

Mitoulis and Bennett [20] examined the effects of waste tyre rubber additive on concrete mixture strength. There was a decrease in the flexural and compressive strength of the concrete by 16% and 38% when 15% by volume of rubber particles of the total coarse aggregates was incorporated in the concrete mixture. For 15% replacement of coarse aggregate with rubber particles in the concrete, the reduction in compressive strength was 57.8% more than the flexural strength. In this study, the variations in concrete quality (in terms of compressive strength) produced from a blend of clay-based concrete admixtures and multiple additives was examined extensively for adequacy and coherency in concrete mixtures used for structural applications.

2. RESEARCH SIGNIFICANCE

The compressive strength of concrete reduces as Clay content present in the sand that constitutes the clay-cement admixture increases. However, the quality of Clay-cement admixture can be improved to optimum percentage when blended with additives. As the title implies, different additives were experimented and the results revealed that concrete with high Clay content can be improved to satisfactory level (suitable for structural applications) when combined with additives with adequate curing durations and mix ratios.

3. MATERIALS

This section provides details of the procedures used in the improvement of concrete with high clay content using different additives to achieve it. The following materials were used in this study: Cement (Portland Limestone Cement), Additives, Coarse aggregate (Crushed granite), Fine aggregates (Sharp sand) and Water (Clean, portable water). Cement (hydraulic binder that sets and hardens by chemical reaction with water) conforming to BS12:1991 was used. The SUPASET brand of cement produced in Akamkpa, Cross River State and sold in Ikot Akpaden, Akwa Ibom State was employed in the study. The cement was well protected from dampness to avoid lumps. Additives used in the study were: Superplasticizer (Conplast SP430), Periwinkle shell Ash, Rice husk Ash and Hydrated Lime. Materials for the sieve size analysis included a set of sieves (4.75, 2.36, 1.18, 0.600, 0.425, 0.300, 0.150 and 0.075) mm including Pan and cover, sieve shaker, weighing balance, oven, brushes, pans etc. Materials for the slump test included a slump cone, scoop, sampling tray, shovel, tamping rod, made out of straight steed bar 16mm diameter and 60 long and rule. Materials for the concrete cube test included 100x100x100 mm cube mould, slide wrench, trowel, 600mm long and Ø16mm Tampering rod, steel rule, compression testing machine, mallet and Lubricating agent (engine oil).

4. METHODS

Cement was purchased and taken to the laboratory in a sealed 50kg bag, while coarse and fine aggregates were obtained from Mkpat Enin L.G.A and transported to the laboratory. The concrete samples were 100mm cubes and the test was carried out in the laboratory. The materials were air dried in the laboratory, the coarse aggregate (granite chippings) were sift with a set of sieves, the portion passing through 20mm sieve aperture and retained on 5mm sieve aperture was used in the study. The fine aggregate used were those passing through 2mm sieve size and retained on sieve 150mm sieve size. All tests were conducted according to the British Standard (BS) (e.g. BS 1881) while the materials were specified according to BS 882, BS 5328, and BS 8110. Hydrolysis experiment was conducted according to the standard by ASTM C192. Aggregate were washed thoroughly to remove dust particles, silt, clay, organic matter and other impurities that would reduce its bonding capacity with the cement paste. It was then separated into various sizes by passing the materials through a series of screens with different size openings. The maximum size of crushed aggregate used was 20mm nominal size produced at Akamkpa. Water was then added in the required quantity, and the workability of the fresh concrete was measured by means of slump test. The concrete mixtures were poured into well-oiled steel mould of 100mm size, and were compacted manually. The moulds were dismantle after 24 hours of casting and cubes were cured in water for 7, 14 and 28 days.

4.1. Concrete Mix Design

This involves the process of selecting suitable concrete materials and determining their relative quantities with the purpose of providing an economical concrete which has certain minimum properties, notably workability, strength and durability. The British mix design method was used to design all concrete mixtures. The design was based on the 28-day strength of $20NM^2$ using ordinary Portland cement type 1, with a coarse aggregate of 20mm size and a crushed fine aggregate. Mix ratio of 1:2:4 and water cement ratio of 0.5 and 0.6 were applied in the production of all concrete specimens used for the experiment. Designed mixes are preferable to prescribed mix or mix by proportion because of the previously laid down specifications limiting the values for a range of properties that must be satisfied. These properties are usually the maximum water/cement ratio, minimum cement content, minimum strength, minimum workability and maximum size of aggregate. Prescribed mix, on the other hand were used where strength is usually of secondary importance; for example, to obtain a special finishing.

4.2. Slump Test

The mould was filled above the top layer with fresh concrete mixed after 2 minutes, in three layers each of approximately one-third of the height of the mould and tamped for 25 strokes each using the tamping rod. Sawing motion of the tamping rod was used to strike off the concrete level from the top of the cone after the top layer was tamped. The cone was removed from the concrete by raising it vertically, slowly and carefully in about 5-10 seconds interval. Immediately after the mould was removed, the slump was measured to the nearest 5mm by using the rule to determine the difference between the height of the cone and the highest point of the specimen being tested. Parameters used for the slump test are presented in Table 1.

Table 1. Parameters used for slump test

Sample No.	Mix Ratio	W/C	Slump Height (mm)	Slump Type (mm)	Additives %
C24,A	1:2:4	0.5	292.00	True	100% Sharp sand (No clay)
C24,B	1:2:4	0.5	165.00	Collapse	100% Sharp sand with high clay content
C25,C	1:2:4	0.6	297.00	True	10% Hydrated lime
C25,D	1:2:4	0.6	298.00	True	10% Periwinkle shell ash
C26,E	1:2:4	0.6	298.00	True	10% Super plasticizer
C26,F	1:2:4	0.6	298.00	True	10% Rice husk ash
C27,G	1:2:4	0.6	290.00	True	5%Each. Periwinkle shell ash+Super plasticizer
C27,H	1:2:4	0.6	293.00	True	5% each. Rice husk ash+Hydrated Lime
C28,I	1:2:4	0.6	285.00	True	5% each. Lime, Periwinkle, Rice husk ash and Super plasticizer
C28,J	1:2:4	0.6	286.00	True	2.5% each. Lime, Periwinkle, Rice husk ash and Super plasticizer

Slump Test Result, Height of Slump Mould=300mm

4.3. Concrete Cube Test

Concrete cube test is a destructive testing method, as the cubes are crushed in compression testing machine in other to determine the maximum strength of concrete after 7, 14 and 28 days. The mould was measured to obtain its length, breadth and height of all inner to inner dimensions accurately with the help of a steel rule. The inside of the mould was thoroughly lubricated with a lubricating agent, which is engine oil. The fresh concrete to be tested was poured into the mould with the aid of a trowel in three Layers of each having height approximately 50mm such that the two layers filled the cube mould as 50+50=100mm. After pouring each layer, the layer was compacted with the help of tamping rod with the bullet ended side stroking into the concrete for 25 Strokes. The top of the mould was trimmed and made smooth with the help of the trowel. After 24 Hours, all the concrete cubes were removed from the moulds and completely immersed in a water tank (curing bag) at room temperature of $28^0C \pm 2^0C$. The completely cured concrete cubes were then crushed to obtain their respective compressive strength at 7, 14 and 28 days. Readings from the crushing machine was recorded and the failure mode was observed. Figure 1a demonstrates the mixing process of additives, Figure 1b demonstrates the mixing process of concrete while Figure 3 demonstrates the pouring process of concrete into mould and preparing it for curing.

a. b. c.

Figure 1. a. Mixing of additives, b. Mixing of concrete, c. Preparing concrete for curing

4.4. Curing

This involves keeping the concrete continuously damped for some days in order to allow it gain more strength, durability and to have water prove characteristics. The main aim is to control temperature and moisture movement from and into the concrete. Moisture affects not only the strength but the durability of concrete. Moreover, curing at normal temperature helps to keep the concrete as nearly saturated as possible, until the originally water-filled space in the fresh cement paste has been occupied to the desired extent by the products of hydration of cement. Curing process of the concrete cubes is shown in Figure 2.

4.5. Compressive Strength Test

For each batch of concrete, two (2) 100mm concrete cubes were subjected to compressive strength test to determine their compressive strengths, two at the age of 7, 14 and 28 days respectively. This test was preceded by weighing of the cubes to determine their densities. After determining the densities, the cubes were each placed on the lower steel platen plate of the machine with both smooth surfaces facing the top and bottom platen plates. Compressive stress/load was then applied at a constant rate of 4.5-9.0KN/sec until the specimen failed. The failure load was recorded according to the gauge readings. Compression testing machine used to perform the compressive test as shown in Figure 3.

Figure 2. Curing of concrete cubes

Figure 3. Compression testing machine

5. EXPERIMENT RESULTS

This section presents the data obtained from the laboratory work and the discussion of the experimental results.

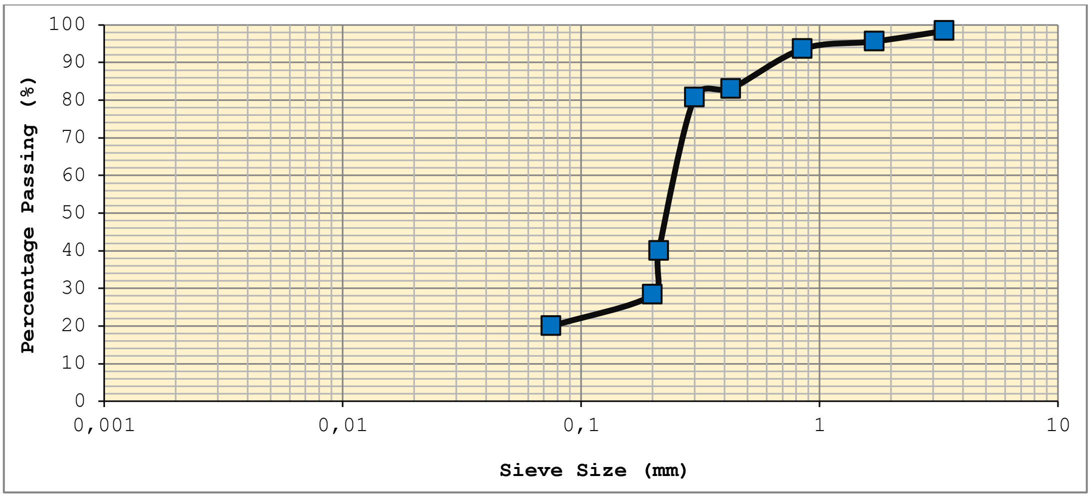

Figure 4. Graph of sieve analysis for fine aggregate

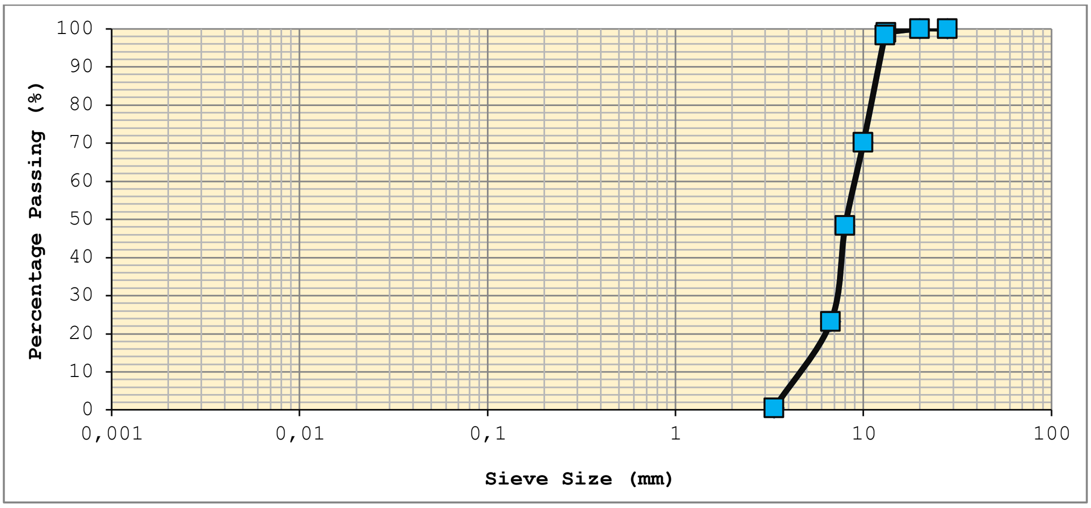

Figure 5. Graph of sieve analysis for coarse aggregate

It should be noted that the directly measured parameters such as the slump test, mass of the specimen, load at failure, which was read from the compression test machine, constitutes direct results while the other results were obtained by rational manipulation of any of these parameters or their combination with any initial data constitute the derived results. Graphical representation of sieve analysis for fine aggregate is shown in Figure 4 while sieve analysis for coarse aggregate is graphically presented in Figure 5 and mix ratios in Table 2.

- **Concrete Batching:**
  Weight of mould=4.952kg
  No. of mould=6
  Volume of mould=0.001m^3
  Concrete weight=2400kg/m^3
  Mix ratio=1:2:4
  Free water cement ratio=0.5&0.60
  Volume of six (6) cubes=6x0.001=0.006
  Weight of concrete in 6 mould=2400x0.006=14.4kg

Table 2. Mix ratio of 1:2:4=7

Amount of cement (kg)	Amount of Fine Aggregate (kg)	Amount of Course Aggregate (kg)	Amount of water (kg)
Mix ratio of 1:2:4=7 at 0.5 W/C			
2.0571 kg	3.84 kg	7.68 kg	0.96 kg
Mix ratio of 1:2:4=7 at 0.6 W/C			
2.0571 kg	3.84 kg	7.68 kg	1.137 kg

- **Density:** Density is the ratio of mass to volume of any substance. It is an important factor that affects the strength of concrete. The results also indicate that the higher the density, the higher the compressive strength which according to Neville and Brooks [21] ranges from 2200 to 2600kg/m^3. In this case, density is mathematically expressed as:

$$Density\ (\rho) = \frac{Mass}{Volume} \quad (1)$$

$$Strength = \frac{Force\ (load)}{Area} \quad (2)$$

$$Area\ of\ cube\ mould = \frac{100*100}{1000} = 10\ mm^2$$

$$Volume\ of\ cube\ mould = \frac{100*100*100}{1000} = 1000\ mm^3$$

Weight of empty head pan=1.466g
Weight of 100mm cube mould=4.952kg

Experimental results obtained from hydrolysis test is graphically presented in Figure 6 while Figure 7 shows the plot of average compressive strength for control concrete (No clay) and high clay concrete using mix ratio of 1:2:4 at 7, 14 and 28 days curing. Figure 8 represents a plot of control samples with combination of two additives at 5% each and all additives at 2.5% using mix ratio of 1:2:4 at 7, 14 and 28 days curing while Figure 9 shows a plot of control samples with combination of two additives used at 5% and all additives at 5% using mix ratio of 1:2:4 at 7, 14 and 28 days curing. Figure 10 indicates a plot of lime ash at 10%, super plasticizer at 10%, rice husk ash and lime ash combined at 5% using mix ratio of 1:2:4 at 7, 14 and 28 days curing while Figure 11 shows a plot of control samples, additives using mix ratio of 1:2:4 at 7, 14 and 28 days curing. Hydrolysis test results (Cm=0.5, Ro=1.9) is tabulated in Table 3. Results showing averages of periwinkle shell ash and super plasticizerSP430 as well as rice husk ash and hydrated lime are presented in Table 4 and 5. Results showing averages of all additives combined at 2.5% each as well as all additives at 5% each are presented in Table 6 and 7.

Table 3. Hydrolysis test result cm=0.5, Ro=1.9

Date	Time (t)	Time Elapsed (t)	Hydrometer Reading Rh	Temperature T° C	Rh+Cm=Rh	Hr	D (mm)	$K(in\%) = \frac{100psRh}{ms(1-ps)}$	K=K ms/m %
29/10/2019	11:50AM	½ min	10.50	27°	11.00	7.5	0.053	35.20	32.42
	11:51	1 min	10.00	27°	10.50	12.5	0.048	33.60	30.98
	11:52	2 min	9.50	27°	10.00	17.5	0.040	32.00	29.50
	11:54	4 min	9.00	26°	9.50	22.5	0.032	30.40	28.03
	11:58	8 min	8.50	26°	9.00	27.5	0.025	28.80	26.55
	12:05	15 min	8.00	26°	8.50	32.5	0.020	27.20	25.08
	12:20	30 min	7.50	26°	8.00	37.5	0.015	25.60	23.60
	12:50	1 hr.	7.00	26°	7.50	42.5	0.012	24.00	22.13
	1:50	2 hrs.	6.50	26°	7.00	47.5	0.009	22.40	20.65
30/10/2019	11:50AM	24 hrs.	6.00	26°	6.50	52.5	0.003	20.80	19.18

$\mathcal{E}k^1/n$= 258.15/10 = 25.82%

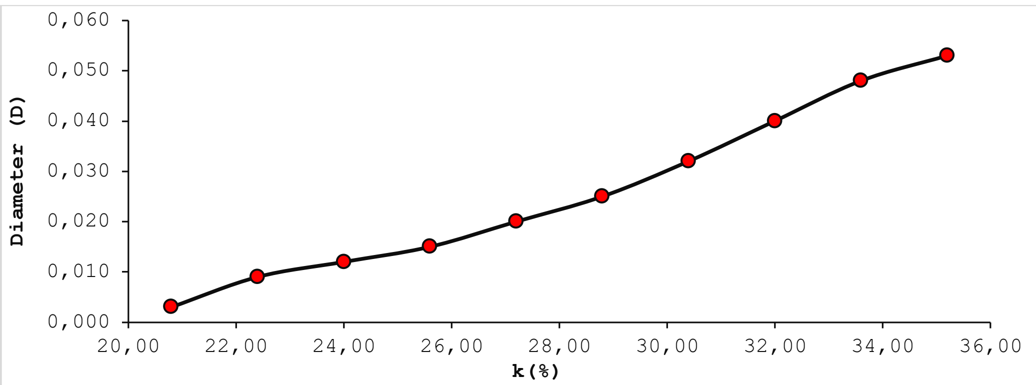

Figure 6. P of hydrolysis analysis test for fine aggregate

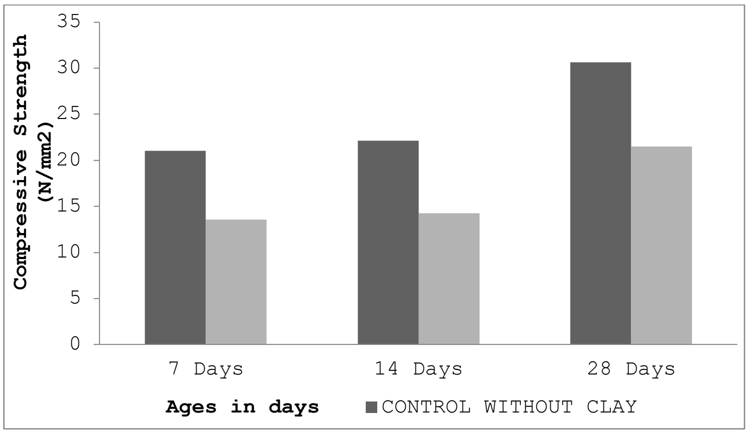

Figure 7. Plot of average compressive strength for Control Concrete (No clay) and High clay concrete using 1:2:4 at 7, 14 and 28 days curing

Table 4. C27A-F average for concrete produced with periwinkle shell ash and super plasticizersp430 at 7, 14 and 28 days curing using 1:2:4

Types of Additives used and percentage	Sample No.	Date Cast	Weight of sample before Curing(kg)	Number of days cured (days)	Weight of sample after curing (kg)	Date crushed	Density Kg/m^3	Crushing Load KN	Strength N/mm^2	Free Water/ Cement ratio
Periwinkle Shell Ash and Super Plasticizer SP430 at 5%Each	C27AB	9/9/2019	1.480	7	2.496	16/9/2019	2480	260.37	26.06	0.6
	C27CD	9/9/2019	2.587	14	2.608	23/9/2019	2587	247.64	24.76	0.6
	C27EF	9/9/2019	2.518	28	2.538	7/9/2019	2518	270.52	27.52	0.6

Table 5. C27G-L average for concrete produced with rice husk ash and hydrated lime at 7, 14 and 28 days curing using 1:2:4

Types of Additives used and percentage	Sample No.	Date Cast	Weight of sample before Curing (kg)	Number of days cured (days)	Weight of sample after curing (kg)	Date crushed	Density Kg/m^3	Crushing Load KN	Strength N/mm^2	Free Water/ Cement ratio
Rice Husk Ash and Hydrated Lime at 5%Each	C27AB	9/9/2019	2.488	7	2.507	16/9/2019	2488	294.71	29.47	0.6
	C27CD	9/9/2019	2.525	14	2.548	23/9/2019	2528	290.20	29.02	0.6
	C27EF	9/9/2019	2.472	28	2.496	7/9/2019	2472	315.20	31.52	0.6

Table 6. C28G-L average for concrete produced with rice husk ash, hydrated lime, periwinkle shell ash and super plasticizerSP430 at 7, 14 and 28 days curing using 1:2:4

Types of Additives used and percentage	Sample No.	Date Cast	Weight of sample before Curing (kg)	Number of days cured (days)	Weight of sample after curing (kg)	Date crushed	Density Kg/m^3	Crushing Load KN	Strength N/mm^2	Free Water/ Cement ratio
All Additives at 2.5%Each	C28GH	10/9/2019	2.414	7	2.430	17/9/2019	2414	179.96	18.11	0.6
	C28IJ	10/9/2019	2.475	14	2.495	24/9/2019	2475	227.87	22.79	0.6
	C28KL	10/9/2019	2.454	28	2.469	8/9/2019	2454	256.84	25.68	0.6

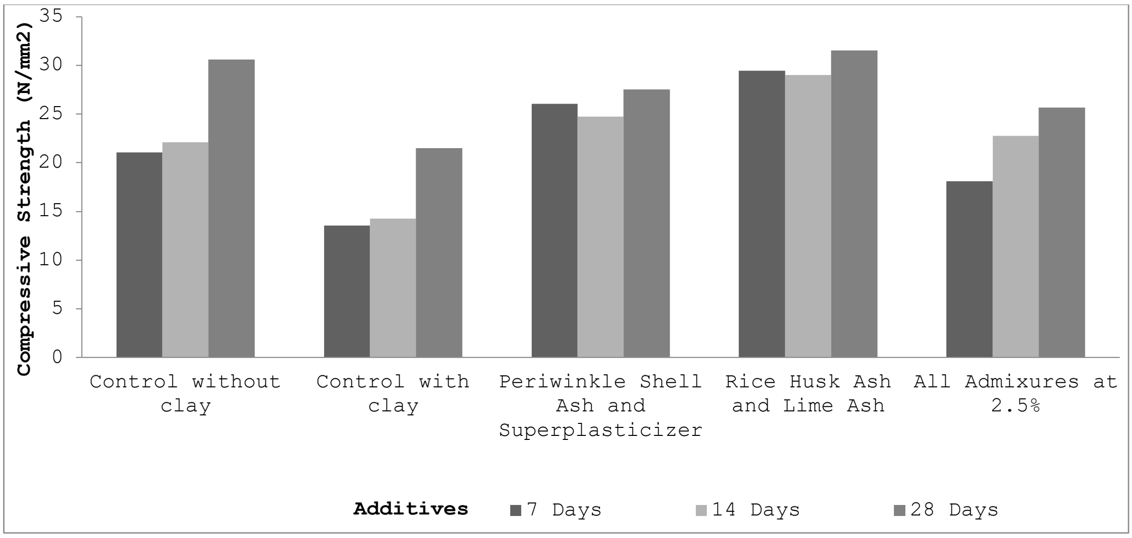

Figure 8. Plot of control samples with combination of two additives at 5% each and all additives at 2.5% using 1:2:4 at 7, 14 and 28 days curing

Table 7. C28A-F average for concrete produced with rice husk ash, hydrated lime, periwinkle shell ash and super plasticizersp430 at 7, 14 and 28 days curing using 1:2:4

Types of Additives used and percentage	Sample No.	Date Cast	Weight of sample before Curing (kg)	Number of days cured (days)	Weight of sample after curing (kg)	Date crushed	Density Kg/m^3	Crushing Load KN	Strength N/mm^2	Free Water/ Cement ratio
All Additives at 5%Each	C28AB	10/9/2019	2.389	7	2.410	17/9/2019	2389	111.45	11.15	0.6
	C28CD	10/9/2019	2.335	14	2.362	24/9/2019	2335	155.20	15.52	0.6
	C28EF	10/9/2019	2.320	28	2.336	8/9/2019	2320	206.42	20.64	0.6

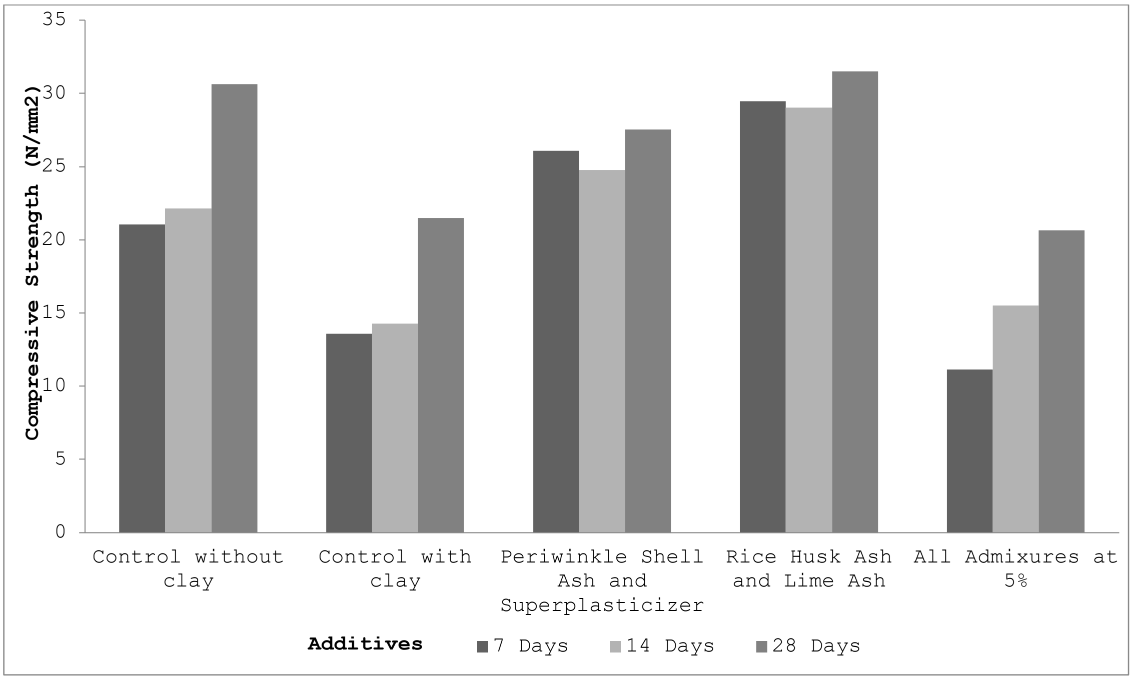

Figure 9. Plot of control samples with combination of two additives used at 5% and all additives at 5% using 1:2:4 at 7, 14 and 28 days curing

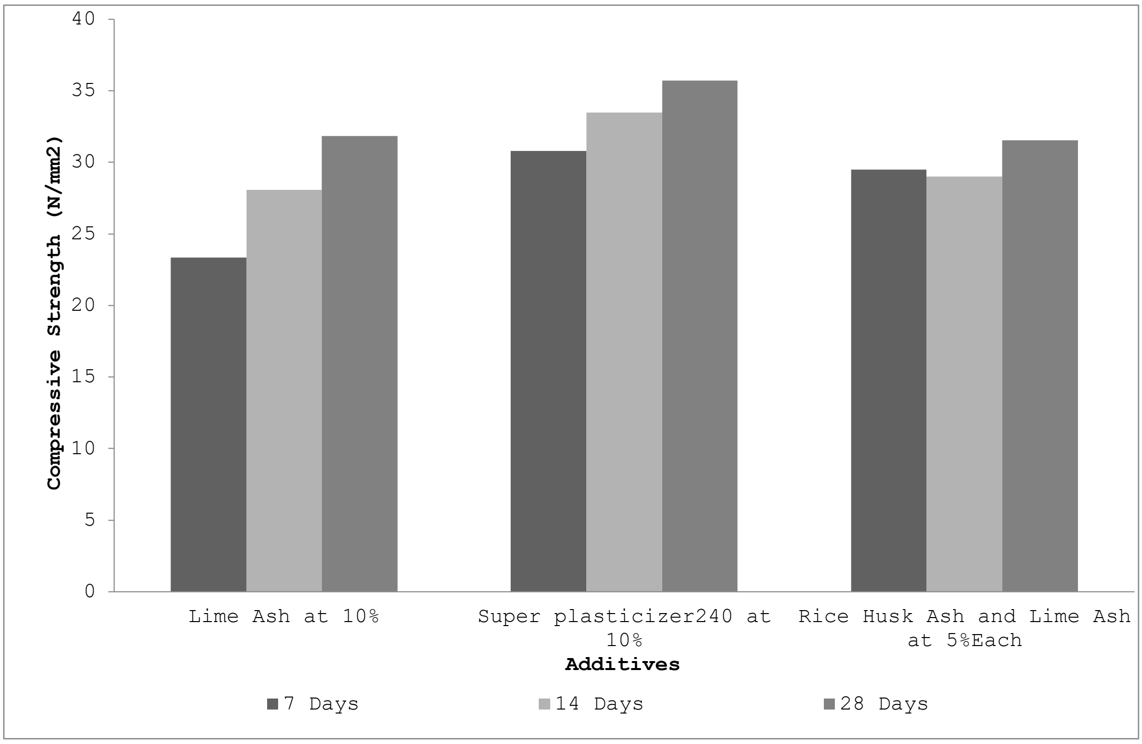

Figure 10. Plot of lime ash at 10%, super plasticizer at 10%, rice husk ash and lime ash combined at 5% using 1:2:4 at 7, 14 and 28 days curing

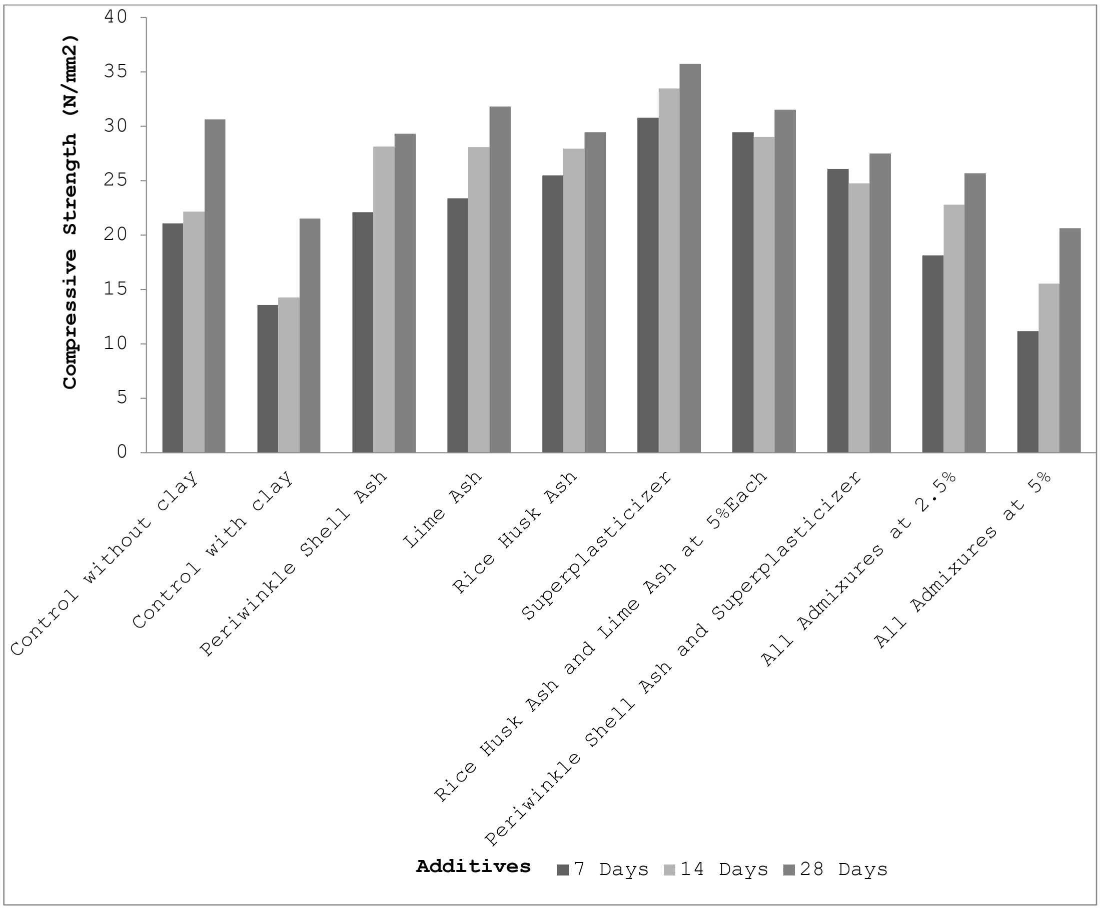

Figure 11. Plot of control samples,additives and its combination with percentages using 1:2:4 at 7, 14 and 28 days curing

From the results of the laboratory experiments, it has been noticed that samples with high clay content had a great reduction in its compressive strength compared to the control samples without clay content. However when additives were added to the samples having high clay content, changes were observed on the compressive strength of all the concrete cubes and recorded appropriately. A total of sixty (60) concrete cubes were cast and the mix design was kept constant at 1:2:4 all through the mixes. Particle size distribution analysis and hydrolysis test were carried out for fresh concrete and cured concrete cubes. Slump test and compressive strength test were also carried out respectively. The results implies that additives can be utilized in concrete mixtures as a good material to improve concrete with high clay content since its gives higher strength. It was noted that for control samples with no clay and high clay content at 7, 14, and 28 days, their compressive strength were 21.05, 22.13, 30.62 and 13.57, 14.26, 21.49N/mm^2 respectively. For Rice husk ash and Hydrated Lime combined together at 7, 14, and 28 days at 5% each, their compressive strength were (29.47, 29.02, 31.52) N/mm^2 respectively. Similarly for periwinkle shell ash and superplasticizer (conplastSP430) combined together their compressive strength at 7, 14 and 28 days were (26.06, 24.76, 27.52) N/mm^2 respectively.

Finally for all the additives combined together at 5% and 2.5% each, compressive strength at 7, 14 and 28 days were (11.15, 15.52, 20.64) and (18.11, 22.79. 25.68) N/mm^2 respectively. From the results obtained, superplasticizer (conplastSP430) at 10% yielded the highest level of compressive strength of 30.78, 33.48, and 35.72 N/mm^2 at 7, 14, and 28 days curing respectively. This suggest that additives can be utilized in concrete with high clay content for improvement within satisfactory levels and percentages. The study further indicate that variations in the properties of additives when combined together can result in significant differences in the performance of concrete made with them.

6. CONCLUSION

This study was carried out to determine the variations in the quality of concrete mixtures produced from the blend of clay-based concrete admixtures and multiple additives. From the results, superplasticizer (ConplastSP430) at 10% had the highest level of compressive strength of 30.78, 33.48, and 35.72 at 7, 14 and 28 days curing. However, control samples with clay content and all sample admixtures at 5% produced the least level of compressive strengths of 13.57, 14.26, 21.49 and 11.15, 15.52, 20.64 at 7, 14 and 28 days curing duration. The results compared to the control samples indicated that concrete mixes with high clay content may not be suitable for structural applications, but could be improved by the use of additives to boost their compressive strength and other required properties to satisfactory level. Hence, the compressive strength of concrete mixtures depreciates with increasing clay content, thereby, reducing the overall quality of mixtures when used in structural applications.

CONFLICT OF INTEREST

The authors declared no conflict of interest.

FINANCIAL DISCLOSURE

The authors declare that this study has received no financial support.

DECLARATION OF ETHICAL STANDARDS

The authors of this article declare that the materials and methods used in this study do not require ethical committee permission and/or legal-special permission.

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