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STRENGTH INDICES OF ALKALINE ACTIVATED LATERIZED CONCRETE WITH SAW DUST ASH (SDA) AS PARTIAL REPLACEMENT FOR CEMENT

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Abstract: The focus of this study is to investigate the physical and strength properties, the flexural and deflection capacity of Alkaline Activated Laterized Concrete (AALC) elements with 5% Saw Dust Ash (SDA) as replacement for cement and 25% laterite replacing fine aggregate in all the mixes. The preparation of AALC was done with a water/binder ratio of 0.4 and a 2.25% dosage of Super Plasticizer for a 1:1½:3 mix ratio. Sodium Hydroxide Pellets (NaOH) were used as activator from 0% to 10% at interval of 2.5% (i.e 0%, 2.5%, 5.0%, 7.5% and 10%) of total mass of binder. A total of 108 concrete cubes (150 X 150 x 150mm) and 108 concrete cylinders (150 x 300mm) were cast, cured and tested at 7, 14, 28, 45, 90 and 120 days for their density, compressive and tensile strengths. Eighteen rectangular beams (150x150x750mm) were also cast and tested for their flexural and deflection capacity. The results show that the initial and final setting time of the cement paste reduced as the percentage of alkaline activator increased in the paste. This same trend was observed for the workability of AALC concrete, but laterized concrete without alkaline activation had better workability. Density, compressive and tensile strength of AALC were found to reduce as the percentage of alkaline activator increased in concrete. The deflection values at failure increased significantly for AALC, the percentage increase in deflection value at failure load for 2.5, 5.0, 7.5 and 10% addition of NaOH compared to normal concrete was 156%, 180%, 209% and 260% respectively. This indicates that AALC has high ductility than normal concrete. The addition of NaOH lowered the load at which visible cracks were observed (20kN and 15kN) for AALC compared to that of normal concrete, which showed visible cracks at a higher load of 50kN. Similarly, the ultimate load at failure of AALC were significantly lower (50kN and 55kN) than that of normal concrete which failed at 90kN. This implies that alkaline activation enhances the deflection capacity of concrete but reduces its load-carrying capacity. The flexural strength and the ultimate moment of AALC concrete were found to decrease as the addition of NaOH increased in the concrete.

Keywords: saw dust ash, laterized concrete, super plasticizer (conplast sp430), compressive strength, splitting tensile strength, flexural strength, deflection capacity

1. INTRODUCTION

Concrete is perhaps, one of the most important building materials, playing a significant role in all Civil Engineering works. The overall relevance of concrete in virtually all Civil Engineering practice cannot be overemphasized. The need to reduce cost of structural materials and therefore increase the affordability and availability of concrete for the ever increasing population is a necessity. In the works of (Mindess et. al., 2003; Sabir et al., 2001) the environmental concerns, stemming from the high energy expense and CO_2 emission associated with cement manufacture, have brought about pressures to reduce cement consumption through the use of supplementary materials. In developing countries where concrete is widely used, the high and steadily increasing cost of cement has made construction very expensive. This has challenged many engineers and researchers to seek and develop new materials relying on renewable resources. This practice involves the use of waste materials and by-products as supplementary constituents of concrete which may improve concrete workability, mechanical properties, and durability. The deleterious effect of cement production on the environment has led to studies on various waste materials termed 'pozzolans' which could be used as partial replacement for cement in concrete works.

Saw dust is an organic waste material from the timber industry. It is produced from the mechanical milling or processing of timber into planks of various shapes and sizes at saw mills. This process is a daily activity causing heaps of saw dust to be generated after each day's work. The dust is usually used as domestic fuel and for filling ditches, in which case, constitutes environmental nuisance. The resulting ash known as saw dust ash (SDA) is a form of pozzolana. Saw dust is in abundance in Nigeria and other parts of the world. Recent discovery that these wastes can be processed and later used as partial replacement of cement in the production of concrete is not only helping to cleanse the environment but also gradually reducing the volume of cement being consumed.

Morsyet al. (2007) in their research opined that when fine pozzolana particles are dispersed in concrete paste, they generate a large number of nucleation sites for the precipitation of the hydration products. Consequently, this mechanism makes the paste more homogenous and dense as for the distribution of the fine pores. This reaction has a way of improving the resistance of the concrete formed to increase in temperatures.

Ivanauskas, (2008) in his study explained that when fine pozzolana particles are dispersed in concrete paste, they enhanced the precipitation of the hydration product. The reaction between the amorphous silica of the pozzolana and the calcium hydroxide ($Ca(OH)_2$) produced by the cement hydration reaction makes the concrete paste to be more homogeneous and dense. The physical effect of the fine grains allows denser packing within the cement and reduces the wall effect in the transition zone between the cement paste and aggregates. This effect of the pozzolana depends not only on the pozzolanic reaction, but on the physical or filler effect of the particles in the mixture. The use of pozzolanic admixtures extends the hydration reaction and produces good micro-pore structures, resulting in improved durability, he concluded.

Raheem et al., (2012) worked on Saw Dust Ash as Partial Replacement for Cement in Concrete. The results showed that SDA is a good pozzolan with combined SiO_2, Al_2O_3 and Fe_2O_3 of 73.07%. The slump and compacting factor decreased as the SDA content increased indicating that concrete becomes less workable as the SDA content increased. The compressive strength decreased with increasing SDA replacement. The compressive strength of concrete with SDA was lower at early stages but improves significantly up to 90 days. An optimum value of 23.26N/mm^2 at 90 days was obtained for concrete with 5% SDA replacement. It was concluded that 5% SDA substitution is adequate to enjoy maximum benefit of strength gain.

Udoeyo and Dashibil (2002) studied Saw Dust Ash as concrete material. The compressive strength of specimens with replacement levels ranging from 10 to 30% cured over periods of 3–90 days showed a decreasing strength with higher ash content. The 28-day split tensile strength of SDA concrete specimens showed a similar trend. The SDA concrete was observed to gain rapid strength at later ages, indicating a pozzolanic activity of the ash. Although only concrete with a 10% replacement level attained the 20 N/mm^2 designed strength at 28 days, test results indicate that SDA concrete can attain the same order of strength as conventional concrete at longer curing periods.

Udoeyo et al., (2006) conducted an experimental research on the physio-mechanical properties of laterised concrete ranging from partial to full replacement of the fine aggregate with laterite. The results presented showed that concrete having 40% replacement of sand with laterite achieved a compressive strength result of 20 N/mm^2.

Hardjito et al (2008) conducted study on the effects of sodium hydroxide concentration on the compressive strength of fly ash-based geo-polymer mortar. The authors reported that alkaline concentration was proportionate to the compressive strength of geo-polymer mortar. They claimed that higher concentration of sodium hydroxide solution result in a higher compressive strength of geo-polymer mortar.

The focus of this research work is to investigate the performance of Alkaline Activated Laterized Concrete (AALC) with cement partially replaced by Saw Dust Ash. The effort is aimed to fully integrate the Laterized concrete for structural use in construction work. The use of SDA as a partial replacement of cement would result in the reduction of the use of cement. The use of Laterite would help preserve the natural soil deposit of the river and also helped to maintain ecological balance.

2. MATERIALS AND METHODOLOGY

The ordinary Portland Cement (OPC), Lafarge super set 32.5 Grade manufactured by Lafarge Nigeria Plc, was used in all mixes throughout this research. The fine aggregate was river sand obtained from Ogun River, Ogun State, Nigeria. The coarse aggregate was crushed granite with a maximum particle size of 12mm and the laterite was sourced from a borrow pit in Ogun State, Nigeria. The water used was potable.

The saw dust used to produce Saw Dust Ash as partial replacement for cement was collected at Oko Baba in Lagos State, Nigeria. The saw dust was dried and burnt in an incinerator to get the Saw Dust Ash (SDA). Conplast SP430 is a Sulphonated naphthalene polymer base chemical admixtures, it was used as the Super-plasticizer with an optimum dosage of 2.25liter per 100kg of cement. Sodium Hydroxide pellets was used as activator from 0% to 10% at interval of 2.5% (0%, 2.5%, 5.0%, 7.5%, 10.0%) of total mass of binder.

The mix ratio of 1: 1.5: 3 and water-binder ratio of 0.4 was used for all the mix proportions. The Saw Dust Ash (SDA) was 5% of the total binder content and Laterited as partial replacement of the fine aggregate at 25% of the total fine aggregate content. A total of 108 concrete cubes (150 X 150 x 150mm) and 108 concrete cylinders (150 x 300mm) were cast, cured and tested at 7, 14, 28, 45, 90 and 120 days. Eighteen numbers of beams (150mm x 150mm x 750mm) were also cast and tested for their flexural and deflection capacity. The mix proportions are as follows:Mix Ratio: (1:1.5:3) (w/c=0.4)

- Batch-1(Control): Cement, Sand, Granite and water.
- Batch-2: Cement, Sand, Granite, water, 0.0% NaOH, 2.25% Super-plasticizer, 5% SDA and 25% Laterite.
- Batch-3: Cement, Sand, Granite, water, 2.5% NaOH, 2.25% Super-plasticizer, 5% SDA and 25% Laterite.
- Batch-4: Cement, Sand, Granite, water, 5.0% NaOH, 2.25% Super-plasticizer, 5% SDA and 25% Laterite.
- Batch-5: Cement, Sand, Granite, water, 7.5% NaOH, 2.25% Superplasticizer, 5% SDA and 25% Laterite.
- Batch-6: Cement, Sand, Granite, water, 10% NaOH, 2.25% Super-plasticizer, 5% SDA and 25% Laterite.

The beam test specimens were placed on two steel supports, one end on a roller support and the other end on a fixed support of 50 mm diameter steel bars. Two 50mm diameter steel bars, a fixed and a roller were alternated to receive the loading from the hydraulic jack through a spreader beam to the test specimens. The whole set-up is made in order to obtain a 3-point loading effect on the specimen. The load was applied through hydraulic jack and measured with a calibrated proving ring of capacity ranging from 0 – 49 tons. The vertical deflections were measured by using two dial gauges positioned directly under the loading supports, having a least count of 0.01 mm. The vertical deflections measured at the centre of the beam specimens was taking as the average of both dial gauge readings. The loadings on the beam specimen was applied incrementally at an interval of (0.5tons) 5kN. The loading arrangement was chosen such that there will be as many numbers of readings as possible. Deflections were recorded for each loading increment. The load at the first crack and the corresponding deflections at the bottom of the beams were recorded. The ultimate failure load and corresponding deflections under the beam specimen were also observed and recorded. The load setup is as shown in Figure 1.

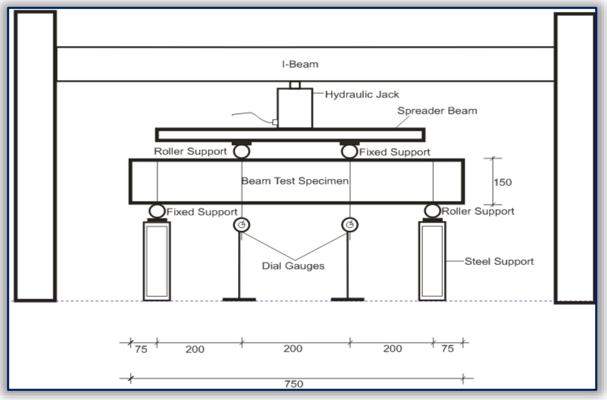

Figure 1: Beam Set-Up for Deflection Test

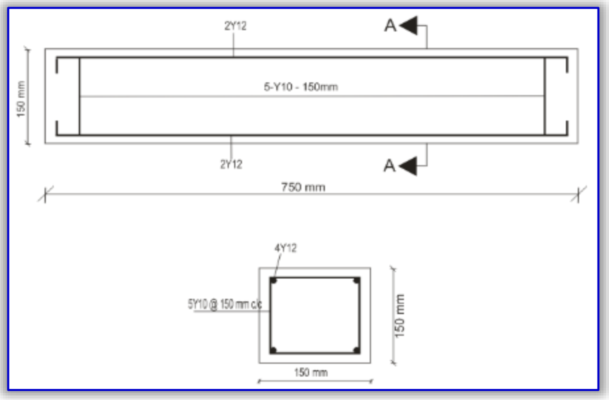

Figure 2: Details of Reinforced Beam Element

A total of eighteen beams (150x150x750mm), three for each concrete mix, were cast, cured over a period of 28days and tested for their deflection and flexural capacity. The reinforcement details of the beams are as shown in Figure 2 below. All beams had the same form of reinforcement.

3.RESULTS AND DISCUSSION

Particle Size Distribution

Figure 3 above shows the particle size distribution of the aggregates used in this experimental work. From the obtained result, the coefficient of uniformity C_u for Sand, Laterite and Granite were determined to be 3.26, 4.17 and 1.63 respectively and the coefficient of curvature C_c were 1.17, 1.71 and 1.38 respectively. The grading coefficients indicate that all the aggregates were suitable for concrete mix.

From the results above, and according to the unified soil classification system ASTM D6913-04(2009) for $C_u > 4$ and $1 < Cc < 3$. Granite is hence classified as well graded. For $C_u \geq 6$ and $1 < Cc < 3$: Sand is hence classified as well graded and Laterite is also classified as well graded.

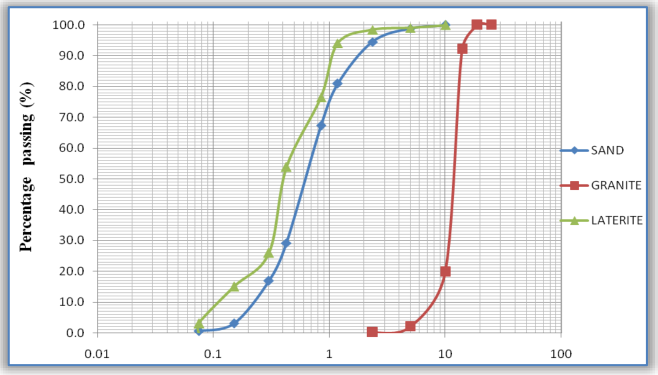

Figure 3: Sieve analysis graph of sand, granite and laterite

Physical Properties of the Materials

Table 1 above gives the physical properties of the aggregates. The bulk density of sand, granite and laterite were found to be 1594.90, 1650.19 and 208.40kg/m³ respectively. The percentage moisture contents for the sand, granite and laterite were 0.3, 0.28 and 0.15 respectively.

Table 1: Physical Properties of Aggregates

Physical Properties	Sand	Granite	Laterite
Uniformity Coefficient (Cu)	3.26	1.63	4.17
Coefficient of Curvature (Cc)	1.17	1.38	1.71
Fineness Modulus	5.09	3.86	4.34
Specific Gravity	2.62	2.65	2.60
Bulk Density (kg/m3)	1594.90	1650.19	1628.40
Dry Density (kg/m3)	1226.85	1289.21	1266.81
Moisture Content (%)	0.3	0.28	0.15
Aggregate Impact Value (%)	-	8.9	-

Setting Time

Table 2 shows that the initial setting time for the control (cement only)was 110 minutes, while the final setting time was 220 minutes. It was observed that the initial setting time of the cement paste with 5% SDA without alkaline activation (0% NaOH), is only 2mins less than that of the control (cement only) but quite a wider margin of 40mins was recorded for the final setting time. Also, it was observed that as the percentage of NaOH increases in the AALC, the initial and final setting times reduced.

Table 2: Effect of the Alkaline Activator, NaOH on the Initial and Final Setting Time of Cement Pastes.

% of SDA	C	5	5	5	5	5
% of NaOH	C	0	2.5	5.0	7.5	10.0
Initial Setting Time (mins)	110	108	60	48	30	18
Final Setting Time (mins)	220	180	100	80	50	30

Workability of AALC

Tables 3 and 4 give the results of the slump and compacting factor test on the fresh concrete mixes to determine their workability. The laterized concrete (with 5% SDA and 2.25% SP) without alkaline activation (0% NaOH) was observed to have the highest slump value of 50mm and compacting factor of 0.92, while the control concrete has a slump value of 35mm and compacting factor of 0.91. This is despite the fact that SDA and laterite have been reported to have relatively high water absorption capacity, Ikponmwosa et al., (2006).

Table 3: Slump Test Results of AALC

	5% SDA and 25% Laterite Replacement for Sand and Cement Respectively					
	Batch 1 Control	Batch 2 0% NaOH	Batch 3 2.5% NaOH	Batch 4 5.0% NaOH	Batch 5 7.5% NaOH	Batch 6 10% NaOH
Slump (mm)	35	50	35	15	10	5
Description	Wet mix	Wet mix	Wet mix	Stiff mix	Stiff mix	Very stiff mix

The higher workability of the laterized concrete without alkaline activation can be attributed to the effect of the super-placizer which is a chloride free super-plasticizing admixture based on selected sulphonated naphthalene polymers. It disperses the fine particles in the concrete mix, enabling the water content of the concrete to perform more effectively.

It was observed that the addition or increase in percentage of alkaline solution content in the concrete reduces the workability of the mix as reflected in the slump and compacting factor values. This is in line with the results of the study by Konda et al. (2010), which indicated that the workability of freshly prepared low-calcium fly-ash based geo-polymer concrete decreases with the increase in the concentration of sodium hydroxide. Figures 4 and 5 show the variation of slump values and compaction factor respectively, with percentage variation of alkaline activator (NaOH).

Table 4: Compacting Factor Test Results for Varying Percentage of Alkaline Activator (NaOH).

Batch	% NaOH	Compacting factor
1	C	0.91
2	0	0.92
3	2.5	0.89
4	5	0.89
5	7.5	0.88
6	10	0.78

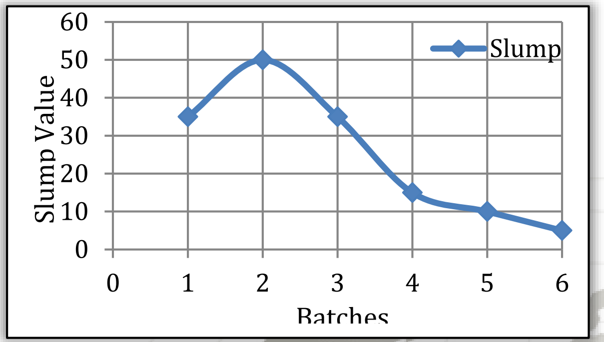

Figure 4: Variation of Slump Values with Percentage Variation of Alkaline Activator (NaOH)

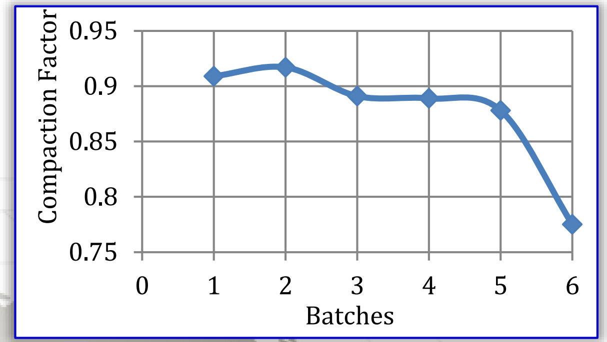

Figure 5: Variation of Compaction Factor Value with Percentage Variation of Alkaline Activator (NaOH)

Densities of Concrete Cubes with Percentage Variation of Alkaline Activator (NaOH).

The results obtained from the experiment as shown in Table 5, gives the density of alkaline activated laterized concrete at varying content of the alkaline activator. The maximum density was found to be 2755.57kg/m^3, for batch-2 concrete at 120 days, while the lowest density was 2340.74kg/m^3 for batch-6 concrete at 7 days. It was observed that density of the cubes increased for all the batches as the curing age increased, but as the Alkaline Activator (NaOH) content increases, concrete density decreased.

Table 5: Relationship between density of concrete cubes and percentage variation of alkaline activator (NaOH).

Batches	Laterite content (%)	NaOH Content (%)	DENSITY (kg/m^3) CURING AGE (Days)					
			7	14	28	45	90	120
1	C	C	2411.85	2482.65	2595.56	2602.66	2660.37	2698.52
2	25	0.0	2414.81	2557.58	2612.00	2684.74	2693.33	2755.57
3	25	2.5	2402.88	2417.78	2500.00	2515.00	2525.00	2560.00
4	25	5.0	2400.86	2409.09	2460.88	2481.90	2491.85	2500.74
5	25	7.5	2388.00	2400.00	2421.22	2455.00	2488.00	2500.00
6	25	10.0	2340.74	2398.48	2415.93	2441.48	2426.67	2432.96

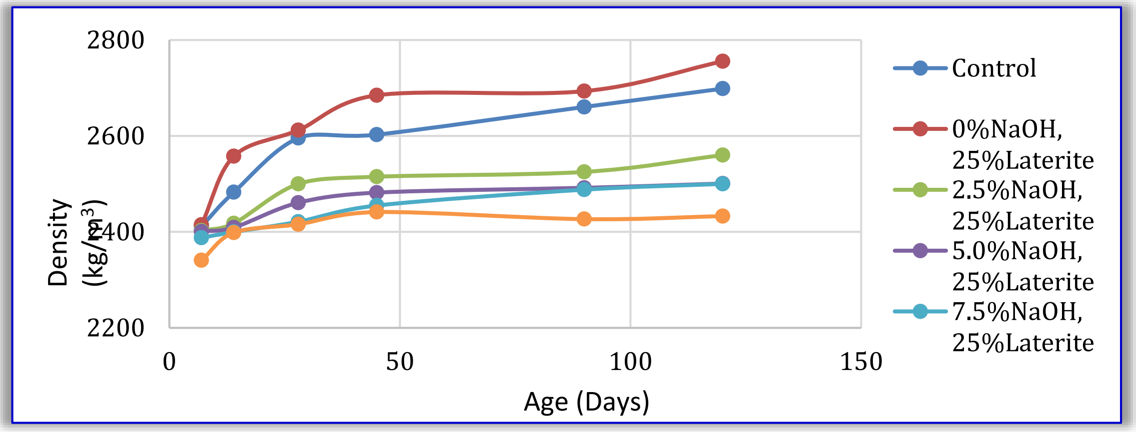

Figure 6: Effect of PercentageVariation of Alkaline-Activator (NaOH) on Density of Concrete (Cubes) with Curing Ages.

Compressive Strength Results of AALC

Table 6 gives the results for the average compressive strength for the control concrete test specimens and AALC test specimens with various percentages of alkaline content. The maximum compressive strength recorded at 120days was 50.52 N/mm^2. This was for batch-2 concrete, this indicates that ordinarily the addition of laterite helps to improve the compressive strength of the concrete. The lowest compressive strength at 120days was found to be 15.75 N/mm^2 for batch-6 concrete. The highest compressive strength at 120days recorded for AALC was found to be 30.25N/mm^2, for batch-3 concrete (2.5% NaOH, the batch with the least alkaline content). For all the mixes, compressive strength increases as the curing age increases but decreases as the alkaline content increases at all curing ages, as shown in Figure 7.

TABLE 6: Average Compressive Strength of AALC

Laterite Content (%)	NaOH Content (%)	Average Compressive Strength (N/mm^2) Curing Age (Days)					
		7	14	28	45	90	120
C	C	27.11	30.22	33.33	42.22	42.59	43.54
25	0.0	31.78	42.22	45.58	46.66	48.22	50.52
25	2.5	15.33	16.55	21.11	22.63	24.05	30.25
25	5.0	8.22	10.22	12.22	14.44	16.88	25.71
25	7.5	6.89	9.11	11.78	12.89	15.56	20.98
25	10.0	4.67	6.95	9.56	10.89	12.44	15.75

Batch 2 concrete (laterized concrete with 5% SDA, 2.25% SP and 0% NaOH), had the highest compressive strength at all curing ages. Most of the strength of this concrete mix was developed at the early age, this is because, in the absence of alkaline activation, the effects of the super-plasticizer in enhancing the concrete to gain strength early is observable.

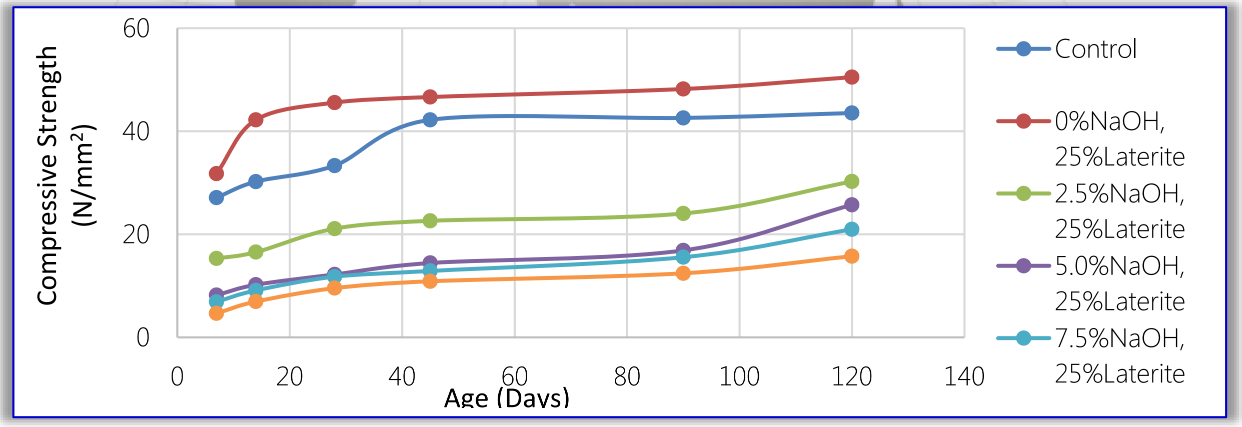

Figure 7: Compressive Strength of AALC at varying percentages of Alkaline Activator (NaOH)

Compressive strength of AALC was significantly reduced when compared to the laterized concrete without alkaline activation (batch-2) and control concrete (normal concrete). The percentage decrease was found to be 40%, 49%, 58.5%, 68.8% for 2.5%, 5.0%, 7.5% and 10% NaOH content respectively, when compared with batch-2 concrete.

Tensile Strength of Cylinders

Table 7 gives the results for the average tensile strength for the control concrete and AALC with various percentages of alkaline content. The maximum tensile strength recorded at 120days was 6.24N/mm^2, it was batch-2 concrete. The lowest tensile strength at 120days was found to be 1.94N/mm^2, for batch-6 concrete.

Table 7: Average Tensile Strength of Alkaline Activated Laterized Concrete.

Laterite Content (%)	NaOH Content (%)	Average Tensile Strength (N/mm^2) Curing Age (Days)					
		7	14	28	45	90	120
C	C	3.35	3.73	4.11	5.21	5.26	5.38
25	0.0	3.92	5.21	5.63	5.76	5.95	6.24
25	2.5	1.89	2.04	2.61	2.79	2.97	3.73
25	5.0	1.01	1.26	1.51	1.78	2.08	3.17
25	7.5	0.85	1.12	1.45	1.59	1.92	2.59
25	10.0	0.58	0.86	1.18	1.34	1.54	1.94

The highest tensile strength recorded for AALC was found to be 3.73N/mm² for batch-3 concrete (2.5% NaOH, the batch with the least alkaline content). For all the mixes, tensile strength increases as the curing age increases but decreases as the alkaline content increases at all curing ages, as shown in Figure 8. Just as in compressive strength results, the tensile strength is significantly reduced for AALC whencompared to laterized concrete without alkaline activation.

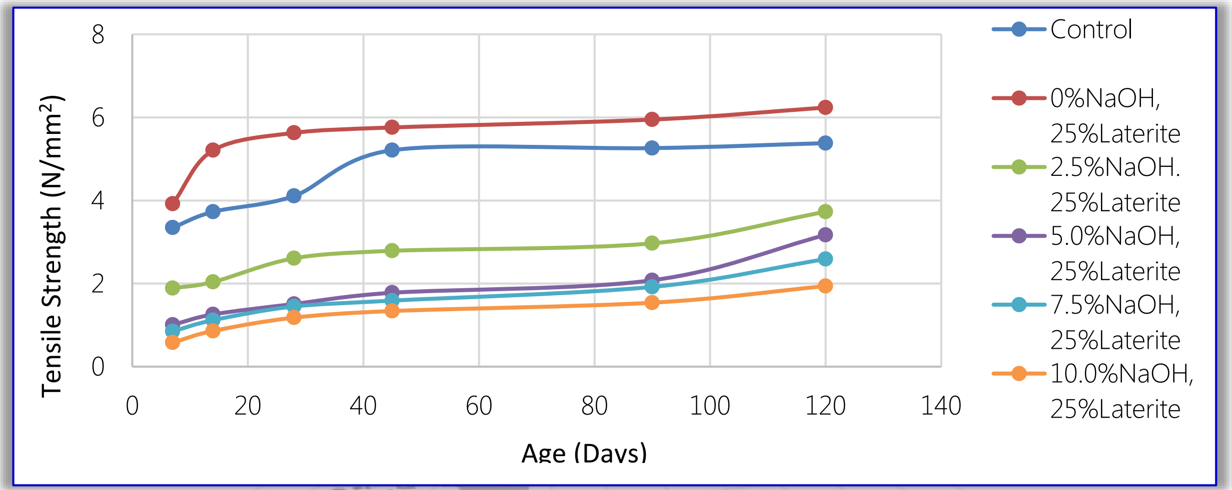

Figure 8: Tensile Strength of AALC at varying percentages of Alkaline Activator (NaOH)

Deflection of Alkaline Activated Laterized Concrete Beams

Table 7 and Figure 9 show the results of the deflection characteristics of the control concrete specimens and the AALC with varying percentages of alkaline activation. All tested beam specimens failed in flexure with a tensile mode, which was characterized by the formation of cracks in the tensile stress zone, bottom and side faces. As the beams were loaded, the first crack was developed on the bottom left side layer under the line load.

Table 8: Load – deflection reading for 28 days concrete beams

Loading Time (sec)	Load (KN)	Deflection (mm)					
		Batch 1	Batch 2	Batch 3	Batch 4	Batch 5	Batch 6
0	0	0.00	0.00	0.00	0.00	0.00	0.00
0.5	5	0.41	0.43	0.31	0.52	0.73	0.51
1	10	0.86	0.91	1.00	0.82	1.03	1.02
1.5	15	1.31	1.38	1.50	1.16	1.37	1.53(Visual Crack)
2	20	1.76	1.86	2.00(Visual Crack)	1.90(Visual Crack)	2.11(Visual Crack)	2.05
2.5	25	2.00	1.86	2.69	2.90	3.11	2.56
3	30	2.18	1.98	3.62	3.23	3.49	4.50
3.5	35	2.39	2.13	5.33	4.59	5.07	11.09
4	40	2.65	2.29	8.81	7.25	8.25	46.96
4.5	45	2.98	2.49	16.93	13.13	15.55	99.88(Final Failure)
5	50	3.40(Visual Crack)	2.73(Visual Crack)	39.55	28.44	35.42	
5.5	55	3.94	3.02	71.20(Final Failure)	77.64(Final Failure)	85.82(Final Failure)	
6	60	4.65	3.37				
6.5	65	5.59	3.80				
7	70	6.87	4.97				
7.5	75	8.65	6.84				
8	80	11.21	10.05				
8.5	85	15.54	13.99				
9	90	27.76 (Final Failure)	20.74(Final Failure)				

More cracks were formed at the right side layer of the line load while the existing crack was enlarged as the loading increased. The cracks propagated through the depth of the beam under the left side layer of the line load. At the ultimate load, the major cracks were observed under the left side of the line load. The maximum deflection was 99.88mm at a failure load of 45kN, for batch-6 concrete. The lowest deflection value observed was 20.74mm at a failure load of 90kN for batch-2 concrete. The normal concrete (batch-1) has a maximum deflection of 27.76mm at a failure load of 90kN. The lowest deflection value recorded for AALC (2.5% NaOH) was 71.20mm at a failure load of 55kN. Generally, AALC beams have higher deflection values than beams without NaOH.

The deflection values at failure increased significantly for AALC compared to the other batches (batch-1 and batch-2). The percentage increase in deflection value at failure load for 2.5, 5, 7.5 and 10% addition of NaOH compared to normal concrete was 156%, 180%, 209% and 260% respectively. Also the high percentage difference in the deflection values between the failure load and the immediate previous load in each of the batches for AALC, were found to be 80.0%, 173.0%, 142.3% and 112.7% compared to normal concrete which was 78.6%. This indicates that AALC has high ductility than normal concrete.

The addition of NaOH lowered the load at which visible cracks were observed (20kN and 15kN) for AALC compared to that of normal concrete, which showed visible cracks at a higher load of 50kN. Similarly, the ultimate load at failure of AALC were significantly lower (50kN and 55kN) than that of normal concrete which failed at 90kN. This implies that alkaline activation with NaOH enhances the deflection capacity of concrete but reduces its load-carrying capacity.

The batch-2 concrete (laterized concrete without alkaline activation) had similar behaviour in deflection with normal concrete (Batch-1), but with lower deflection values. This may not be unconnected with the hydration process observed in this batch in the compressive and tensile strength results, where most of the strength were developed at the early ages.

Effect of Alkaline Activation on Flexural Strength and Ultimate Moment.

Table 9 shows the results of flexural strength of AALC beam specimens, at both cracking and ultimate load, and the ultimate moment. The maximum flexural strength was $8.89 N/mm^2$ and $16 N/mm^2$ at first appearance of cracking and ultimate load respectively. This was recorded for the normal concrete.

Table 9. : Flexural Strength and Ultimate Moment of AALC

Batch	% Addition of NaOH	Cracking Load (N)	Ultimate Load (kN)	Flexural Strength at Cracking Load (N/mm^2)	Flexural Strength at Ultimate Load (N/mm^2)	Ultimate Moment (kN.m)
1	C	50	90	8.89	16.00	9.00
2	0	50	90	8.89	16.00	9.00
3	2.5	20	55	3.56	9.78	5.50
4	5.0	20	55	3.56	9.78	5.50
5	7.5	20	55	3.56	9.78	5.50
6	10	15	45	2.67	8.00	4.50

The batch-6 concrete had the lowest flexural strength of 2.67 and $8 N/mm^2$ at cracking and ultimate load respectively. The results show that at both cracking and ultimate load, flexural strength reduces as the percentage of NaOH increased in the concrete. This is not unexpected as the deflection values for AALC have been observed at lower magnitude of load compared to normal concrete. Also, the ultimate moment for normal concrete was 9kNm, this is the maximum moment recorded. The lowest ultimate moment was recorded for batch-6 (10% NaOH) concrete, as 4.5kNm. The ultimate moment decreases as the addition of NaOH increased in the concrete.

4. CONCLUSION

- The initial and final setting time of alkaline activated cement paste with 5% SDA decreased as the percentage of alkaline activator increased in the paste.
- Workability of AALC decreased as the percentage of NaOH increased in the concrete, but laterited concrete with 5% SDA and 2.25% super plasticizer without alkaline activation had better workability than normal concrete and AALC.
- Laterited concrete without alkaline activation (batch-2) had the maximum density of $2755.57 kg/m^3$, higher than normal concrete. Density was observed to decrease as the percentage of NaOH increased in the concrete.
- The compressive and tensile strength of AALC were found to decrease as the percentage of NaOH increased in the concrete.The percentage decrease for compressive strength was found to be 40%, 49%, 58.5%, 68.8% for 2.5%, 5.0%, 7.5% and 10% NaOH content respectively, when compared with batch-2 concrete (the batch with the highest compressive strength value).

- » The maximum deflection was 99.88mm at a failure load of 45kN, for batch-6 concrete. The deflection values at failure increased significantly for AALC compared to the other batches (batch-1 and batch-2). The addition of NaOH lowered the load at which visible cracks were observed (20kN and 15kN) for AALC compared to that of normal concrete, which showed visible cracks at a higher load of 50kN. Similarly, the ultimate load at failure of AALC were significantly lower (50kN and 55kN) than that of normal concrete which failed at 90kN. This implies that alkaline activation enhances the deflection capacity of concrete but reduces its load-carrying capacity.
- » At both cracking and ultimate load, flexural strength decreases as the percentage of alkaline activator increased. This trend was also observed for the ultimate moment of the beams.

5.RECOMMENDATIONS

From the results obtained, the following recommendations would be made:

- The use of admixtures to improve the workability and strength of AALC concrete is recommended.
- For further research, the use of higher percentages of Saw Dust Ash (SDA) in concrete should be done.

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