IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)
e-ISSN: 2278-1684,p-ISSN: 2320-334X, Volume 15, Issue 4 Ver. IV (Jul. - Aug. 2018), PP 54-61
www.iosrjournals.org

Pozzolanicity and Effectiveutilization of Agro-Waste Materials forConventional Concrete Production.

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Abstract: *The need to reduce the high cost of Ordinary Portland Cement in order to provide accommodation for the populace has intensified research into the use of some locally available materials that could be used as partial replacement for Ordinary Portland Cement (OPC). A pozzolan is a siliceous and aluminous material which in itself possesses little or no cement value but which will in finely divided form and in the presence of water react chemically with calcium hydroxide at ordinary temperature to from compounds possessing cement properties. In this research three different pozzolans were used separately as partial replacement of cement in concrete, these are Rice Husk Ash (RHA), Cassava Peel Ash (CPA) and Periwinkle Shell Ash (PSA). Chemical composition, consistency, setting time, slump test and compressive test were carried out on fresh concrete and hardened concrete containing the ashes (RHA, CPA and PSA) respectively as partial replacement for cement. Concrete mixes of 1:2:4 were prepared containing the ashes at replacement level of 0%, 5%, 10% and 20%, and test was carried out on the 7th and 28th day curing ages. The results showed that at 7 days, the maximum compressive strength was obtained at 5% replacement for RHA (14.52N/mm^2) and for 28 days curing age the result showed that 20% replacement level at (19.77N/mm$^{2.}$) is workable for lightweight concrete It was concluded that RHA, CPA and PSA yielded favourable compressive test results however RHA takes the lead in terms of availability.*

Keywords – *Cement,Pozzolans, Compressive Strengths, and Lightweight Concrete*

Date of Submission: 05-08-2018 Date of acceptance: 22-08-2018

I. Introduction

In many countries around the world, people live in substandard housing. Due to insufficient incomes, some are forced to use makeshift housing from scrap materials such as metal, glass orcardboard, which creates unsafe and inhumane living conditions.It is widely accepted the use of pozzolanic materials such as flyash and micro-silica as partial replacement of Portland cement to produce mortars and concretes. Concrete is one of the most widely used construction products in the world, this is so because, concrete production does not necessarily require highlyskilled labour hence locally sourced materials such as sand, gravel and water in addition to ordinary Portland cement(OPC) powder. Several studies in developing countries, including Guyana, Uruguay, Thailand, Pakistan and Brazil, have shown that rice husk ash (RHA) can be used as a partial replacement for cement in concrete[20]. This ability to use an agricultural waste product to substitute a percentage of Portland cement would not only reduce the cost of concrete construction in these countries, but would also provide a means of disposing of this husk, which has little alternative uses.Several studies have shown that due to its high content of amorphous silica, rice husk ash can be successfully used as a supplementary cementitious material in combination with cement to make concrete products [1]Additionally, cement manufacturing is an energy-intensive process, so in addition to reducing the cost of concrete construction and providing a means for disposing of an agricultural waste product, incorporating RHA into concrete as a partial substitute for Portland cement would also stand to reduce the amount of energy associated with concrete construction.The effectiveness of a pozzolan depends on its pozzolanic reactivity and this concept may include two factors, namely, the maximum amount of calcium hydroxide that can react with the pozzolan and the speed at which the pozzolanic reaction occurs [17].Several agro wastes have been found suitable for concrete production by different researchers, according to [16], they discovered that corn cob ash produced under controlled temperature of 600^{o}C yielded favourable result of 18.44N/mm^2 at a controlled and regulated temperature of 600^{o}C for two hours.in a separate paper of [9] they found that rice husk ash react best when heated and burnt at a temperature of500$_o$C for two hours Periwinkle shells (PS) have been used by the people of the coastal states e.g. Rivers State of Nigeria for over 30 years as conglomerate in concrete reinforcement. These shells have been used for many purposes e.g. for homes, soak-away, slabs and road construction. The cost of these shells was 10 times cheaper than that of local coarse aggregate as at the time of this study. Cassava peel (CP) is a by-product of cassava processing, either for domestic consumption or industrial uses. [2] reported that cassava peel constitutes between 20-35% of the weight of tuber, especially in the case of hand-peeling. Based on 20% estimate, about 6.8 million tonnes of cassava peel is generated annually and 12 million tonnes is expected to be produced in the year 2020. Indiscriminate disposal of cassava peels due to gross under-utilization as well as lack of appropriate technology to recycle them is a major challenge, which results in environmental problem. Thus, there is need to search for alternative methods to recycle them (cassava peels).[21] studied the pozzolanic potential of cassava peel ash (CPA) and their results showed that cassava peel ash possesses pozzolanic reactivity when it is calcined at 700^{o}C for 90 minutes. At these conditions, CPA contained more than 70 per cent of combined silica, alumina and ferric oxide. The these results on ternary blended cements were based on the ternary blending of OPC with an agricultural by-product pozzolans (RHA, PSA and CPA). Being majorly agrarian, many communities in South Eastern Nigeria have continued to generate tons of agricultural and plant wastes such as cassava waste (the peelings from cassava tubers),Rice husk and Periwinkle shell as efforts are intensified toward food production and local economic ventures. Not much work has been done in considering the prospects of binary blending of these materials with OPC and nothing has been reported with regard to ternary blending of Nigerian agricultural by-products with OPC. The common periwinkleLittorinalittorea isone of the most abundant marine gastropods in theNorth Atlantic, but Tympanotonusfuscatus is commonlyfound in the estuaries and mangrove swamp forestof the South - South region of Nigeria as opined by [5]. Massive periwinkle harvesting has been reported from some communities in this region of Nigeria.[14]. [13]investigated the effect of the ash on the concrete compressive strength up to 28-days hydration period. The use of PSA as partial replacement of cement in concrete by these authors only investigated the effect of varying percentages of the ash on the compressive strength of the concrete produced.

II. Experimental Procedures

A. Materials

The materials used for this research were locally sourced rice husks (RH), cassava peels (CP) and periwinkle shells (PS), crushed coarse aggregates (granite) locally sourced, ordinary Portland cementconforming to [3],[4][8], Sand (Fine aggregate), Granite (Coarse aggregate) and clean and deleterious-free water.[6]

B. Methods

The coarse aggregates were locally obtained from *a* quarry along *Ise*road, Ikere-Ekiti in Ikere*LocalGovernment* in Ekiti State, Nigeria, the granite obtained later underwent the sieve analysis to ensure even distribution of aggregate sizes in the concrete mi was ensured. The fine aggregate used for this research work was river bed sandobtained from a local supplier in Ado localgovernment area of Ekiti State. The preparation of test samples were in accordance with [6].The RH obtained was sieved using mechanical sieves to ensure organic-free samples were retained and subjected to further cleansing using distilled water, this was later subjected to calcining process using a muffle furnace at a controlled temperature of 600^{o}C for 60minutes due to its high combustion nature to obtain the rice husk ash (RHA). In order to achieve a clean CP, the obtained CP was thoroughly washed with distilled water and later allowed to dry before calcining process took place at a temperature of 850^{o}C for 90 minutes to obtain the cassava peel ash (SPA). In likewise manner, the PS obtained were thoroughly cleaned and washed with distilled water until free of organic matters and later subjected to drying process before calcining at temperature of 850^{o}C using a muffle furnace for a period of 2hours to obtain the periwinkle shell ash (PSA). The ashes obtained were later sieved using a 75µm sievesize to obtain a further finer particles in likely form of OPC.The elemental and oxide composition of the OPC, RHA, CPA and PSA were determined using an energy dispersive x-ray fluorescence (EDXRF) machine at Center for Energy Research in AfeBabalola University (ABUAD)in accordance with BS [4]. Workability tests for concrete such as standard consistency, slump and setting time were determined in accordance with [5]. The concrete mixes were batched by volume and subjected to replacement level of 0%, 5%, 10%, 15% and 20% of each agro waste for OPC. Determination of compressive strengthwas in accordance with British Standards for a mix of 1:2:4 at different curing ages of 7and 28 days.

III. Results And Discussion

A. Chemical Composition Oxide

From table 1.0, Rice Husk Ash (RHA), Cassava Peel Ash (CPA) and Periwinkle Shell Ash (PSA) have higher percentage of SiO_2 than Ordinary Portland Cement (OPC). The CaO composition of Ordinary Portland cement was higher than that of the Rice Husk Ash (RHA), Cassava Peel Ash (CPA) and Periwinkle Shell Ash (PSA) combined.

This indicates that the three agro-wastes are good pozzolanic materials and belong to Class A group of pozzolanic classification.

Table 1.0: Oxide Composition of the Agro wastes and OPC Cement

S/N	1	2	3	4	5	6	7	8
COMPOUND	CaO (%)	SiO_2 (%)	Al_2O_3 (%)	MgO (%)	Fe_2O_3 (%)	SO_3 (%)	Na_2O (%)	K_2O (%)
OPC	63.500	21.000	5.500	3.250	2.050	2.000	0.980	1.210
RHA	2.070	85.003	0.597	0.401	1.297	0.118	0.163	3.423
CPA	10.007	54.720	10.303	6.979	2.226	1.980	0.980	11.880
PSA	35.183	51.910	1.811	12.310	3.672	1.610	1.060	0.700

B. Slump Test

Table2.0 and figure 1.0shows the results generated from the three materials in different percentages at 0%, 5%, 10% and 20%. The materials treated are OPC/RHA, OPC/CPA, and OPC/PSA

Table 2.0: Slump test result

	Control mix 0%	**5%**	**10%**	**20%**
RHA	29.00	26.30	23.48	16.54
CPA	29.00	24.70	22.67	15.70
PSA	29.00	23.54	20.65	16.00

Slump mix ratio =1:2:4, Water binder ratio = 0.65

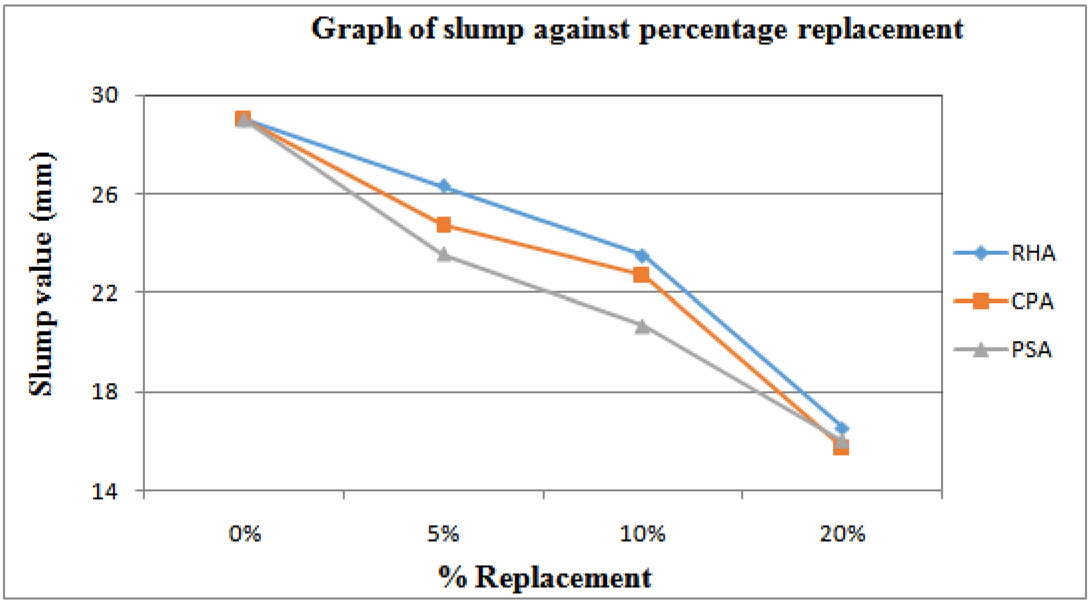

Figure 1.0: Graph of slump value @ different replacement level.

Table 2.0 shows that, the more the RHA, CPA and PSA increase the more the workability of the concrete decreases to the control (0%) the percentage of the workability at RHA decrease by 2.70%, 5.52% and 12.46%. the percentage of the workability at CPA decrease by 4.30%, 6.33% and 13.30% and the percentage of the workability at PSA decrease by 5.5%, 8.35% and 13.00%

C. Standard Consistency Test

Table 3.0: Result of standard consistency test

	Control Mix@0%	**RHA**			**CPA**			**PSA**		
		5%	10%	20%	5%	10%	20%	5%	10%	20%
Consistency	28%	30%	31%	32.3%	33.6%	34.5%	36.8%	31.3%	33.7%	34.9%
Depth of Penetration	29.8	30.5	31.9	32.4	32.4	33.5	37.4	31.5	32.2	33.5

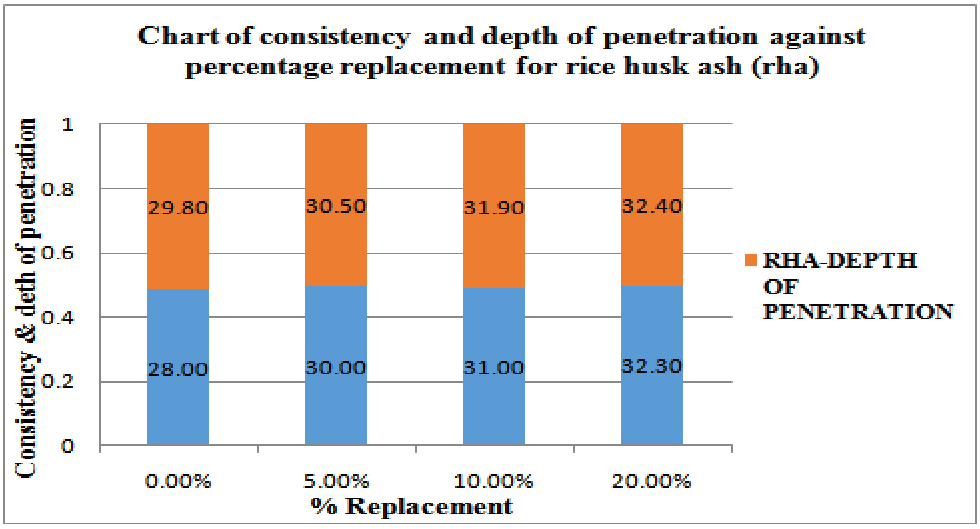

Figure 2.0: Graph of consistency and depth of penetration against %replacement for RHA

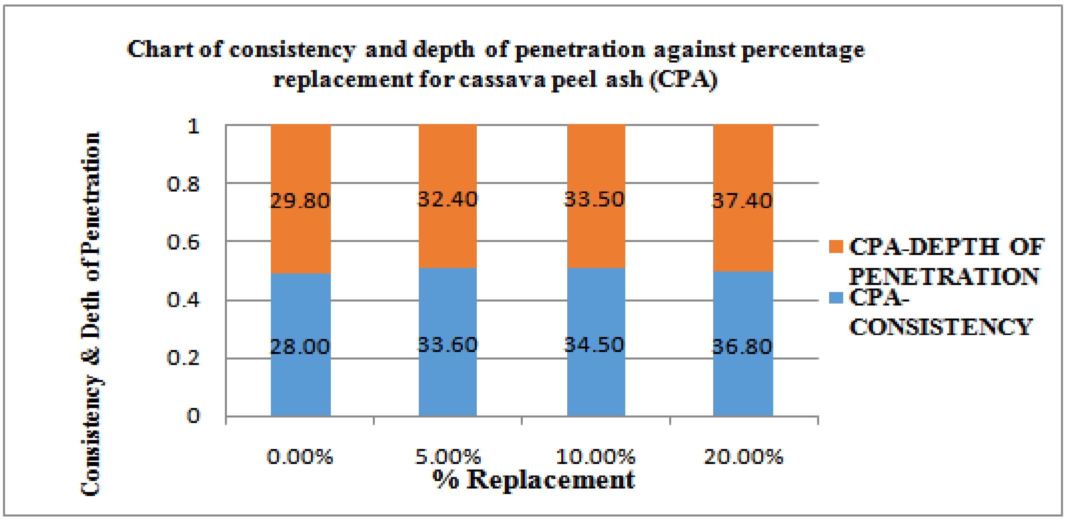

Figure3.0: Graph of consistency and depth of penetration against %replacement for CPA

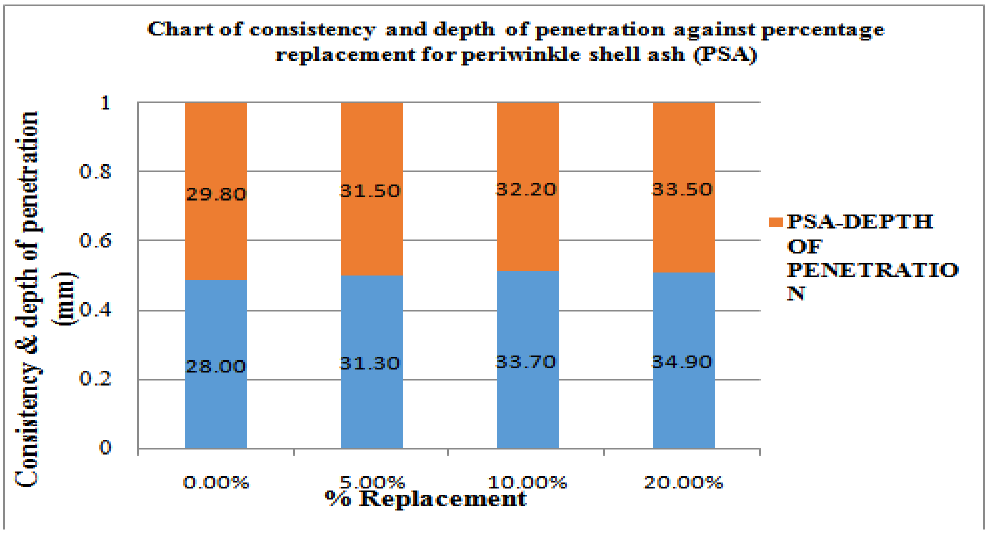

Figure 4.0: Graph of consistency and depth of penetration against %replacement for PSA

D. Setting Time Test

Table 3.0 and figures 5-7show the result of initial and final setting time of ordinary Portland cement (OPC) for the three agro-wastes used as partial replacement of cement. It can be deduced that percentage replacement increase has significant effect on the setting time property of the concrete. The more the percentage replacement, the more the initial and final setting time for all the agro-wastes.

Table 3.0: Setting time result

	Control Mix @ 0%	RHA			CPA			PSA		
		5%	10%	20%	5%	10%	20%	5%	10%	20%
Initial setting time (min)	54.3	58.5	65.2	78.4	62.2	73.6	82.0	78.2	86.6	97.7
Final setting time (min)	145.5	153.3	168.2	185.4	163.5	173.5	193.5	183.5	198.4	208.5

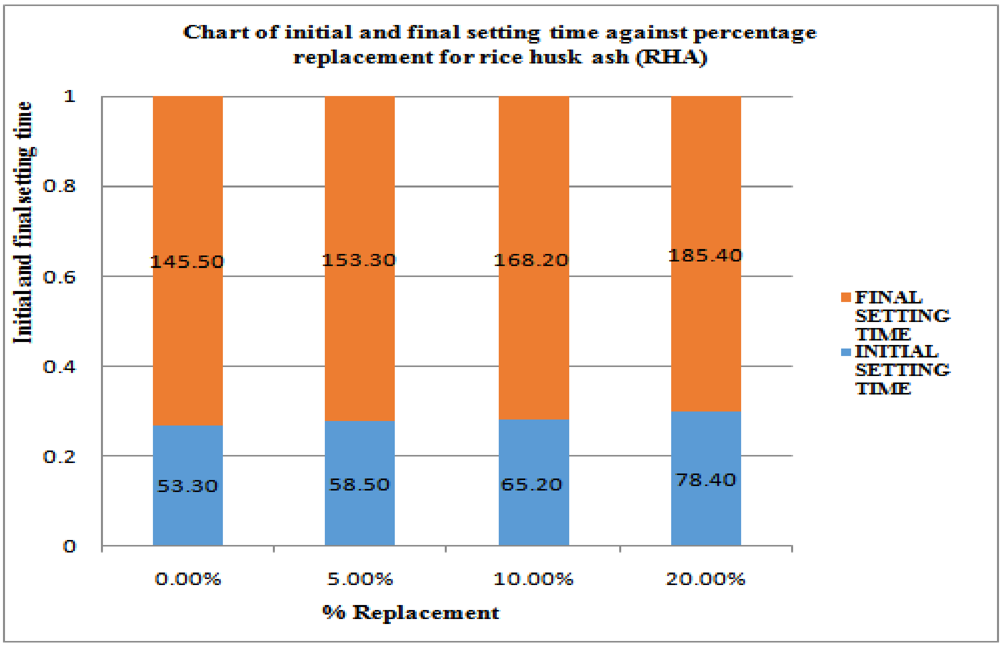

Figure 5.0: Setting time graph of RHA

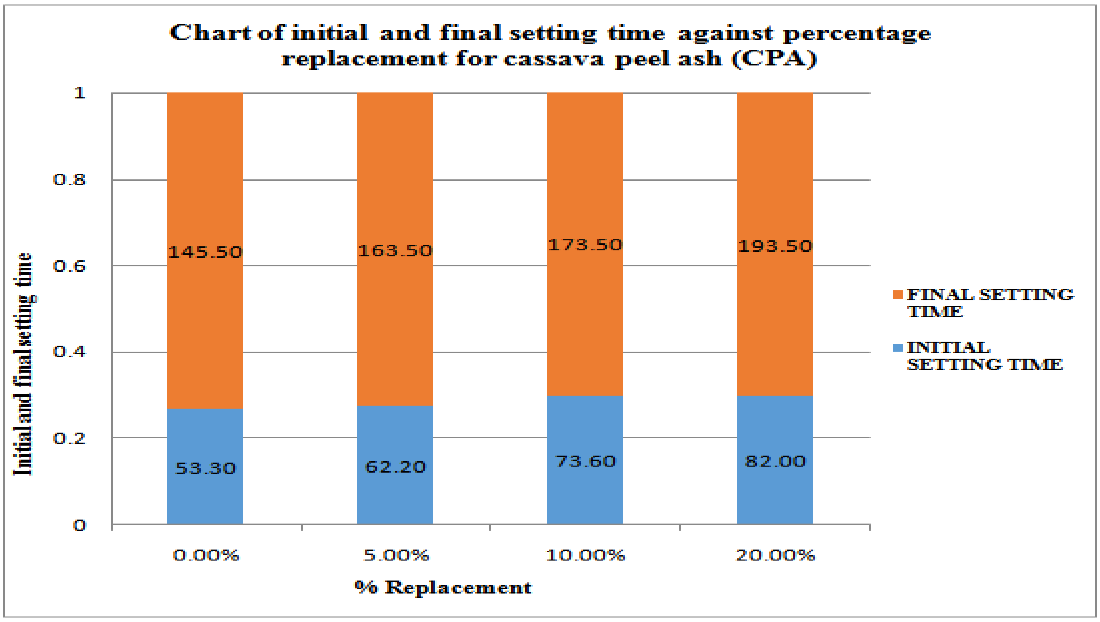

Figure 6.0: Setting time graph of CPA

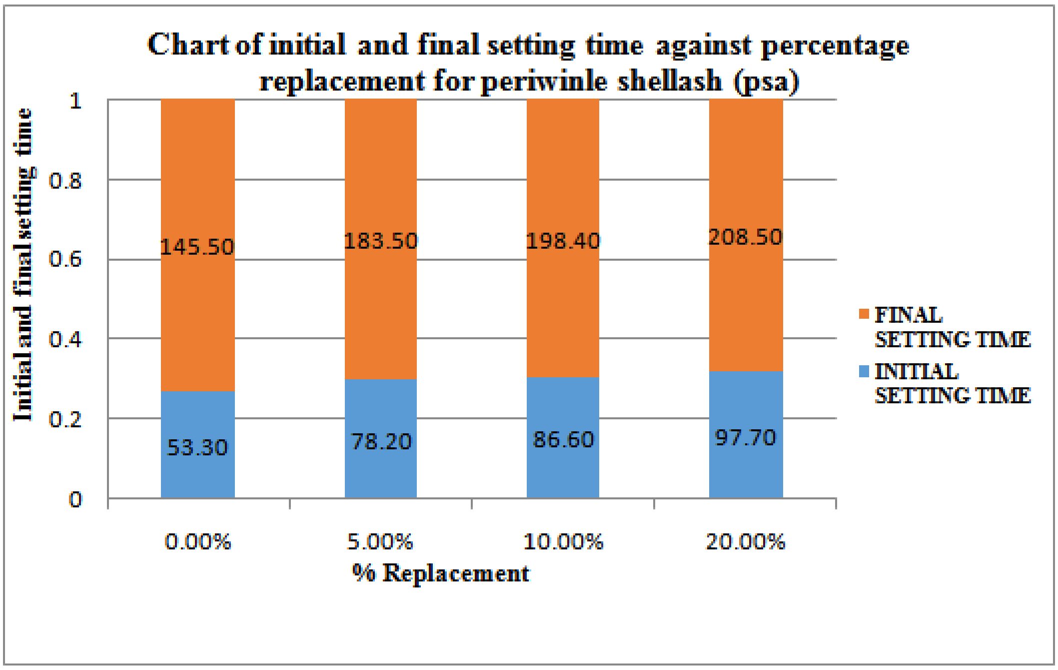

Figure 7.0: Setting time graph of PSA

E. Compressive Strength results

Table 5.0 shows combined results of compressive strength results for each curing ages at each replacement level for the agro wastes, while figures 8 and 9 shows the graphs of compressive strengths of the concrete against percentage replacement for each agro-waste for 7 days and 28 days curing ages respectively.

The result shows initial gain of compressive strength of 14.87N/mm^2 for CPA at 7 days curing age when OPC is replaced at 5%, meanwhile RHA improved better at 28 days curing age when OPC is replaced up to 20%.

Table 5.0: Compressive strength results

AGE (Days)	Percentage replacement (%)	Average Compression Strength (N/mm^2)		
7		RHA	CPA	PSA
	0	15.31	15.31	15.31
	5	14.52	14.87	14.40
	10	13.48	14.32	14.26
	20	12.47	14.05	13.81
28		RHA	CPA	PSA
	0	22.20	22.20	22.20
	5	21.02	20.24	20.17
	10	20.88	18.89	19.86
	20	19.77	18.33	17.93

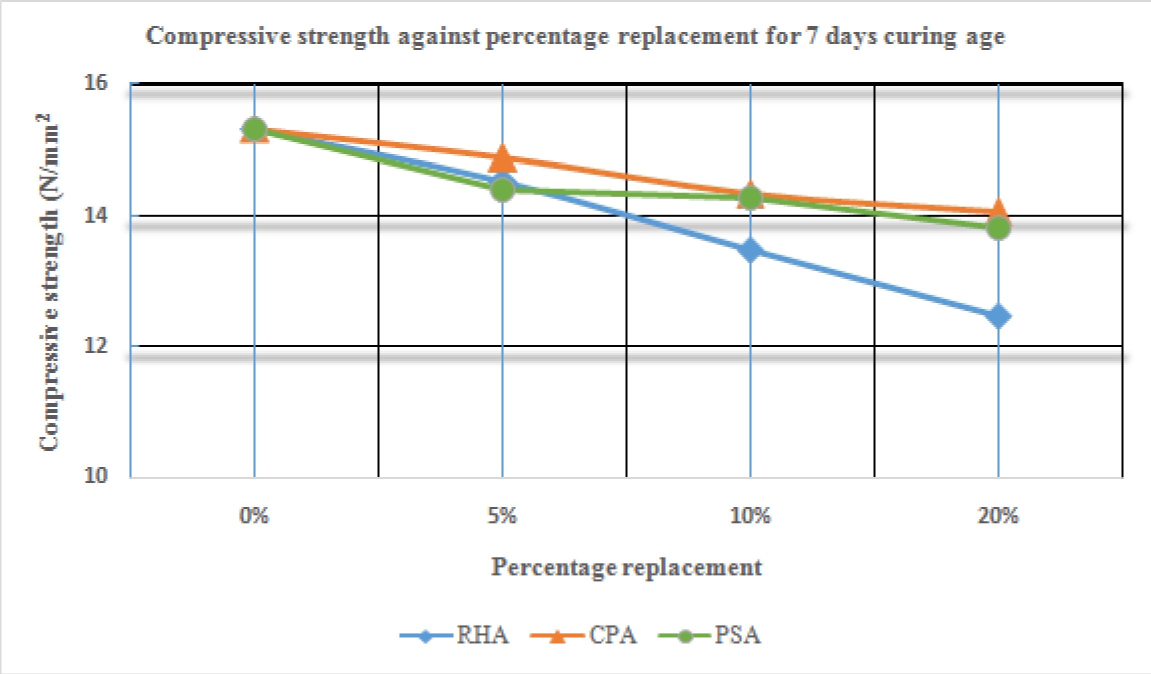

Figure 8.0: Graph of compressive strength for 7 days curing age

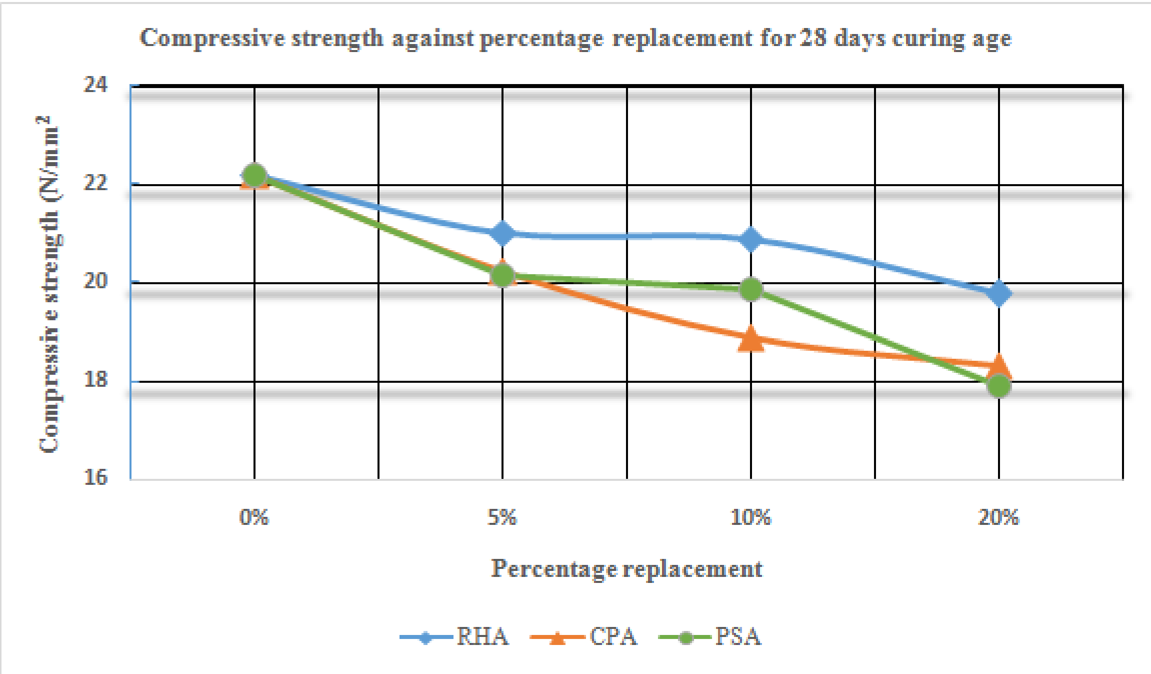

Figure 9.0: Graph of compressive strength for 28 days curing age

VI. Conclusion

It is evident that the various materials (RHA, CPA and PSA) investigated possessed adequate pozzolanic properties to be used in place of cement and their engineering properties in terms of workability and compressive strength is suitable for light weight concrete production. However, effective utilization of these materials would be achieved when RHA is allowed to replace OPC at a maximum replacement level of 20% to yield a considerable engineering result.

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Aoladapo Silas Akinkunmi Pozzolanicity and Effectiveutilization of Agro-Waste Materials for Conventional Concrete Production. ." IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) , vol. 15, no. 4, 2018, pp. 54-61