Structural Integrity of RPPA and URPPA Concretes in the Built Environments

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Abstract
Plantain peels are considered to be used in various ways especially as admixtures which propagates better concrete qualities and for soil stabilization. Plantain is botanically known as Musa paradisiaca, with about 68 species in global existence. Its origin can be traced back to South-Eastern Asia and are currently grown via irrigation processes and naturally grown in swampy and mangrove zones of the globe. This R&D aimed at structurally evaluating the applications of both "Ripe Plantain Peel Ash (RPPA) and "Unripe Plantain Peel Ash" (URPPA) in concrete for the development of the built environments. The cardinal objective of this research is to determine the effectiveness of the use of PPA as supplements in OPC and to generally appraise the efficacy of PPA concrete in construction processes. Methodology employed are based on BS code of practice, ASTM, SON-NIS 444-1 and German standards DN 51043. However, major chemical and physical characteristics as evaluated for RPPA and URPPA in the combined form of SiO_2 + Al_2O_3 + Fe2O3 are 50.52 and 70.7, while LOI are 2.49 and 2.17, with specific gravity as 2.61 and 2.62, so also moisture contents are 77.96% and 79.86% respectively. Similarly, the average density and the compressive strength of the RPPA concretes at 56 days period of curing is 2448.01 (kg/m^3) and 34.22 (N/mm^2) at 5% with 2390.00 (kg/m^3) and 26.14 (N/mm^2) at 25% while for URPPA is 2449.00 (kg/m^3) and 34.27 (N/mm^2) with 2394.10 (kg/m^3) and 26.58 (N/mm^2) respectively. In conclusion, URPPA has proven to be effective supplementary material to be used for partial replacement in cement for structural development when compared to URPPA. RPPA and URPPA is recommended for use when late strength growth is required in concretes with little water requirement.

Keywords: *OPC, PPA, Specimen, Concrete, Workability, Density & Compressive strength.*

1.0 Introduction

Musa paradisiaca, it's a botanical name for Plantain, it is however, a large plant perennial crop Herbaceous Musaceae. Plantain historical origin can be traced back to South-Eastern Asia (IITA, 1997); (Inusa, 2007) and (Ogidi *et al*., 2018). Scientific research data shows that there are about 68 species of plantains in global existence and are from two major hybrids (FAO, 2013). Bananas also belongs to Musaceae family which is also known botanically as Musa sapientum and Musacavandish. It's equally important to note that both plantains and bananas are cultivated and consumed in large quantities in most African countries, with special reference to Nigeria (Muhammad K.R., 2005); (Engberger et al., 2006); (USDA, 2012 and 2017). Research revealed that Africa produces about 50% to 55% of the global production of plantains and bananas (FAO 1990) while 61% of these 50% productions are from West African countries (FAO, 2012). Similarly, both plantain and bananas differs in both available fruit nutrients i.e. food source and peels. Plantain contains carbohydrates, while the bananas fruits contains sugar as according to (Hugues, 2005) 1976 reports. However, according to (Dahiru, 2016) research has shown that PPA can be an effective admixture when use in concrete.

1.1 Background

As reported by (Mantell, 1942 and Harborne, 1984), resins in plant are characterised for having effective binding mechanisms. Plantain peels are considered to be used in various ways especially as admixtures which yields better qualities in concretes productions and soil stabilization when used effectively. However, there exists different forms of admixtures available for usage, and this depends widely on their integral property requirements such as; accelerators, air-entraining agents, pigments, plasticizers, pozzolanas, pore fillers retarders, water reducers and super plasticizers (Neville, 2003); (Pillai and Menon, 2010)..
According to (IFAD, 2011) results shows that plantain fruit (peel and food) are built of several minerals which are natural organic nutrients of elements in the form of; *"Zn, V, Sn, Si, Se, P, Ni, Na, Mo, Mn, Mg, K, I, Fe, F, Cu, Cl, Cr, Co, Ca, and As"* (Lahava E, 1995) and (Ogidi *et al.*, 2018).. Recent published research by (Ogidi *et al.*, 2017) revelled that plantain peels has up to 78.74% moisture content.
Structurally, according to Oluwaseun and Olatunji (2019) concretes are referred to as composite material which are composed of filler as well as binder, while the part of Portland-cement pastes that acts as an effective binding mechanism, usually functions in binding the filler together so as to form a synthetic bonding material. It can be recalled from (Jackson and Dhir, 1998), that admixtures ranges from the addition of chemicals to the application of material wastes which had been advocated for usage ever since cement was first conceived for use in concrete structures. Similarly, according to (Jackson and Dhir, 1998) and (Anitha, 2016) admixtures are used in order to modify or improve fresh or hardened concretes properties. BS EN 206–1 defines admixtures as; The addition of certain material(s) through concrete mixing processes in smaller magnitudes and proportionate to the cement volume during specific mixes (usually within the range of 0.2% to 5% of the concrete volume) so as to modifying the state of fresh or hardened concretes properties. Admixtures are generally recognised as materials which contributes immensely in the productions of cost-effective as well as durable structural concretes. The use of admixtures contributions includes easy handling of fresh concrete. Similarly, it makes placements as well as compaction of concretes much easier, it also provides thaw resistance and reduces the permeability of hardened concretes (Trif, 2014).

2.0 Research Aim

This research aimed at structurally evaluating the sustainable of using "Ripe Plantain Peel Ash (RPPA) and "Unripe Ripe Plantain Peel Ash" (URPPA) in concretes, for the built environments.

2.1 Research Objectives:

1) To examine the chemical composition of "Plantain Peel Ash" (PPA);
2) To determine the efficacy of the use of PPA as partially replacement for "Ordinary Portland cement" (OPC);
3) Similarly, to determine the effects of chemical exposure on compressive strength of PPA concretes;

4) To also evaluates the effect of weight losses and density of PPA concretes at various percentage replacement in concretes; and
5) To generally appraise the efficacy of PPA concrete in construction processes.

3.0 Methodology

3.1 Fundamental Methods

According to (Saleh M. A. et al. 2020) the most effective methods to be adopted in the cause to meeting this research aims and objective, are basically in line with the following analytical code of practices: British standard (BS) "for particle size distribution" (BS 812-1: 1971), and (BS 8110-1: 1997); and for determining concretes compacting factor (BS 1881-103: 1983), while (BS 1881-102: 1983) for analysing slump test. Hence, BS EN 12350-2 (2009) is for "fresh concrete testing" Similarly, for "Portland cement specification and grading in concrete" are "(BS EN 12: 1989), (BS 12: 1991) and (BS EN 197-1: 2011) respectively. Furthermore, (BS 1881-116: 1983), (BS 812-103: 1985), (BS EN 12390-3: 2002) and (BS EN 12390-3: 2009)" determines concretes compressive strengths. While, (BS 3148: 1993) is for proportional use of water in producing fresh concrete mixes, and (BS 812 – 1: 1975) evaluates natural moisture content of cements. BS 4550-3: 1978 is "for physical testing of cement".

Furthermore, analytical laboratory consistencies and efficacies of this research work were compared on the scales of the following standards.

1) ASTM "(American Society for Testing and Materials)" 2012 namely:
   - C311/C311M-13 "Sampling and testing of natural pozzolanas"
   - C187-98 "Standard hydraulic cement paste consistency"
   - C1611/161M-14 "Workability of self-consolidating concretes paste"
   - C191-13 "Vicat needle setting period of cements" and
   - C109/109M-02 "Concrete cube strength requirements".
2) Standard Organisation of Nigeria (SON) "NIS 444-1: 2003 specifications, compositions and conformity benchmarks for common cements" and
3) DIN 51043 of 1979 (German standards) for cement testing and pozzolanas.

3.2 Concrete Proportional Mixes, Cube Casting and Curing

Plantain Peel Ash (PPA) for RPPA and URPPA will be substituting (replacing) percentage (%) by mass volume of OPC i.e 5%, 10%, 15% 20% and 25% standard mix design of 1:2:3 (Cement, River sand and Crushed rocks) with a free water-cement ratio of 0.55 in accordance to BS EN 1008 (2002) *table 1*. And in each case, a standard concrete cubes will be prepared from 150x150x150 mm mould size, while respective weights are determined for each mould and sample (fresh and dried). Subsequently, the cubes will be removed from mould for curing in fresh water tank(s) for a periods of 7, 14, 21, 28 and 56 days *table 3*, with the aim to determining the respective compressive strengths of dehydrated concretes after attaining designated curing dates *table 5 and 6* respectively.

4.0 Result and Discursion

Table 1: Samples Preparation and Substitution Requirements

Constituent Materials and Units	**Substitution Levels**					
	OPC	**RPPA and URPPA**				
	100%	**5%**	**10%**	**15%**	**20%**	**25%**
Cement, C (kg/m^3)	300	295	290	285	280	275
PPA (RPPA and URPPA) in (kg/m^3)	00	05	10	15	20	25
Water, W (kg/m^3)	165	165	165	165	165	165
Fine aggregate (kg/m^3)	667	667	667	667	667	667
Coarse aggregate (kg/m^3)	1268	1268	1268	1268	1268	1268
Free water-binder ratio requirement	0.55	0.55	0.55	0.55	0.55	0.55

Source: (Authors research specimen preparation requirement)

Table 2: Chemical Properties of OPC, RPPA and URPPA

Specimen Chemical Properties Test	**Control Specimens**		**Research Specimens**	
	OPC 1 (%)	**OPC 2 (%)**	**RPPA (%)**	**URPPA (%)**
CaO (Calcium oxide)	60.79	65.03	2.21	4.14
$CaSO_4$ (Calcium Sulphate)	0.29	0.33	0.00	0.01
SiO_2 (Silicon dioxide)	19.26	24.69	45.96	62.76
Al_2O_3 (Aluminum oxide)	4.32	5.01	2.66	3.49
Fe_2O_3 (Iron oxide)	4.10	4.30	1.90	3.91
MgO (Magnesium oxide)	2.50	4.09	5.87	5.1
SO_3 (Sulphur trioxide)	0.78	1.65	0.60	0.64
K_2O (Potassium oxide)	0.21	0.39	0.13	0.24
Na_2O (Sodium oxide)	0.16	0.20	0.24	0.19
P_2O_5 (Phosphorus pentaoxide)	0.13	0.08	4.09	6.18
$SiO_2 + Al_2O_3 + Fe_2O_3$	**27.68**	**34.00**	**50.52**	**70.16**
Specimen Physical Properties Test				
Moisture content (%)	47. 96	69. 49	77.96	79.89
LOI Temp. Range 500^oc - 1000^oc	3.02	3.52	2.49	2.17
Specific gravity	2.89	3.14	2.61	2.62

Source: (Authors Analytical results)

4.1 Chemical analyses of RPPA and URPPA

Analytically, both the chemical and physical results above, can be deduced that the two control samples chosen from two different OPC (OPC1 and OPC2) manufacturing sources, OPC 2 presents most effective results option for having the best pozzolanic characteristics to serve as control for this research work, and it's also obvious that OPC 2 characteristics revels much denser constituent materials, likewise OPC 2 confirms higher moisture content as well as LOI value when compared to OPC 1 *table 2*. Therefore, OPC 2 is herein being adopted as control specimen for this research work. Similarly, the percentage SiO_2 + Al_2O3 + Fe_2O_3 of OPC 2 is greater than that of OPC 1 to the ratio of 34% and 28%. This then will slows the reactivity process and the cementitious requirements as against 70% minimum standard requirement spelt by 1978 ASTM C 618 Part 78. Similarly for RPPA and URPPA

50.52% and 70.16% hence these are greater values comparable to that of OPC1 and OPC2 respectively.
Furthermore, the chemical analysis for natural pozzolanas of URPPA and that of RPPA in *table 2*, in comparison to DIN 51043 of 1979 and ASTM, 2012 (C311/C311M-13 standards specifies a rage between 50% - 67% available SiO_2 proportions, while ASTM C 618 of 1978 part 78 specifies a minimum value requirements of 70% compositions. However, RPPA falls below standard requirement value for having 45.96%. While URPPA falls within the required standards range for having a value of 62.76%. Similarly, both OPC1 and OPC2 produce a research results values of SiO_2 to be 19.26% and 24.69% respectively. These results are below standard requirements for naturally occurring pozzolana in reference to DIN 1979 and ASTM 2012 accordingly.
Similarly, it's significant to outline that; SiO_2 is a major and most effective structural components of admixture that can effectively stimulates pozzolanic reactions in the form of non-crystalline structures. Hence, in this result comparession, it can be deduced that RPPA fall a bit below minimum standard specifications.

4.2 Workability and Slump Examinations of RPPA and URPPA

As it can be deduced from *table 3* below, there is virtually no variation between the results of both RPPA and URPPA when compared with that of the controlled OPC at 5% replacement levels with 0.55% water ratio. This is so evident because the replacement level is said to be minimum. However, reflections of results variations between the specimens and control sample became visible at substitution levels of 10%, 15%, 20% and 25% respectively. The specimens (RPPA and URPPA) became more workable (increased workability) above that of OPC with the same water ratio at 10% RPPA and URPPA = 22% slump value as against 21% slump of OPC, an increased slump value of 4.76% is recorded. Furthermore, at 15% RPPA and URPPA are 24% and 23% slump, which translates an increased slump value of 14.29% and 9.53% Similarly at 20% its equal to 24% and 25% respectively, which is an increased values of 14.29% and 19.53% walkability values. Finally, at 25% replacement values of RPPA and URPPA, the slump values are 26% of the same increased values, this translates an increased slump values of 23.81% when compared to that of the control OPC at 21% slump value. Hence, RPPA and URPPA cumulative slump values are observed to be greater than that of OPC in each case of replacement during the cross-examination of the respective workability of both RPPA and URPPA.

Table 3: Results of Workability (Slump) Test and Concrete Cubes Casting

Replacement Levels (%)	**Constant Water ratio**	**OPC Avg. Slump Value (mm)**	**RPPA Avg. Slump Value (mm)**	**URPPA Avg. Slump Value (mm)**
00	0.55	21	21	21
05	0.55	21	21	21
10	0.55	21	22	22
15	0.55	21	24	23
20	0.55	21	24	25
25	0.55	21	26	26
Concrete Cube Preparation				
Cube Curing Periods	**Replacement Levels**	**OPC Required**	**RPPA Required**	**URPPA Required**

(days)		Cubes (5x5)	Cubes (5x5)	Cubes (5x5)
7, 14, 21, 28, 56	00	25	--	--
7, 14, 21, 28, 56	05	--	25	25
7, 14, 21, 28, 56	10	--	25	25
7, 14, 21, 28, 56	15	--	25	25
7, 14, 21, 28, 56	20	--	25	25
7, 14, 21, 28, 56	25	--	25	25
Cubes Casting	--	**25**	**125**	**125**
Total Numbers of Cubes Casted for Used				**275**

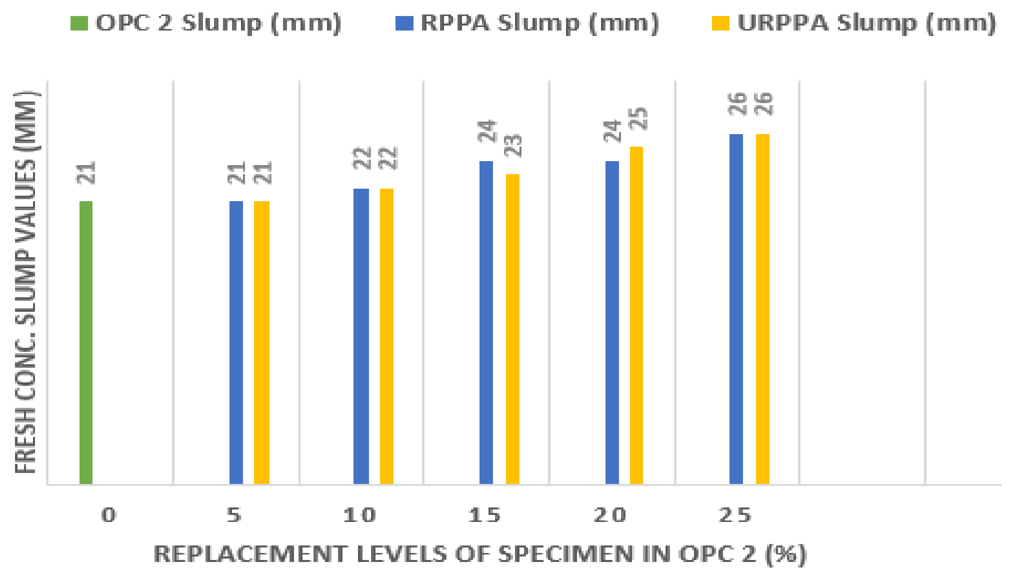

Figure 1: Workability (slump) Value of OPC 2; RPPA and URPPA

Table 4: Average Density (kg/m^3) of Dehydrated Concretes Cubes over Curing Periods

Dehydrated Conc. Cubes	Curing Periods	Replacement Levels (%)					
		00	05	10	15	20	25
OPC 2	7	2313.88	--	--	--	--	--
	14	2320.26	--	--	--	--	--
	21	2365.35	--	--	--	--	--
	28	2409.22	--	--	--	--	--
	56	2448.77	--	--	--	--	--
RPPA	7	--	2309.93	2300.88	2303.49	2298.78	2288.95
	14	--	2314.29	2310.98	2309.59	2299.07	2290.95
	21	--	2362.99	2336.99	2314.40	2309.75	2291.00
	28	--	2400.66	2354.44	2350.57	2335.82	2314.93
	56	--	2448.01	2418.21	2404.17	2400.94	2390.00
URPPA	7	--	2311.66	2311.03	2302.52	2300.02	2287.19
	14	--	2323.30	2320.04	2313.46	2305.65	2293.90
	21	--	2364.93	2338.46	2328.06	2311.18	2300.00
	28	--	2410.04	2402.01	2396.11	2390.99	2388.19
	56	--	2449.00	2421.00	2414.79	2402.21	2394.10

4.3 Densities of OPC, RPPA and URPPA

Analytically, the relative average density of concrete cubes produced from 100% OPC as control specimen from *table 4* above, can be deduced that from 7 days to 56 days cube curing, the concrete cube average density gained an incremental strengths from 2313.88 (kg/m^3) to 2448.77 (kg/m^3) respectively.

Similarly, for the average density of concrete cubes produced with partial substitution of RPPA and URPPA can be stated that, across the row for 7 days curing, the respective cube densities decreases with 5, 10, 15, 20 and 25% substitution levels of RPPA are 2310, 2301, 2304, 2299 and 2289 (kg/m3) respectively. In analysis, it can be stated that the characteristic resultant densities of RPPA for 14, 21, 28 and 56 days curing across the rows are virtually the same in comparession to that analyzed in 7 days aforementioned for RPPA.

Furthermore, the results of URPPA cubes across the row depicts similar characteristics as in the case of the results in RPPA for 7 days curing, the respective cube densities decreases with 5, 10, 15, 20 and 25% substitution levels of URPPA are 2312, 2311, 2303, 2300 and 2287 (kg/m^3) respectively. Hence, this is the same characteristic cube densities of URPPA for 14, 21, 28 and 56 days curing across URPPA rows.

Generally by analyzing along the table columns above, RPPA and URPPA results presents a continuous increasing cube densities with increasing cube curing from 7, 14, 21, 28 and 56 days respectively.

Table 5: Mean Compressive Strength of RPPA in Concrete Cubes (N/mm^2)

Samples Curing Periods (days)	**100% OPC 2** Mean Compressive Strength N/mm^2	**5%** RPPA Mean Compressive Strength N/mm^2	**10%** RPPA Mean Compressive Strength N/mm^2	15**%** RPPA Mean Compressive Strength N/mm^2	**20%** RPPA Mean Compressive Strength N/mm^2	**25%** RPPA Mean Compressive Strength N/mm^2
7	26.84	26.41	25.18	24.88	24.39	24.00
14	27.13	26.59	26.00	25.38	24.99	24.35
21	28.56	27.90	26.49	25.88	25.49	25.01
28	29.22	28.59	26.89	26.28	25.67	25.38
56	34.97	34.22	30.73	27.25	26.66	26.14

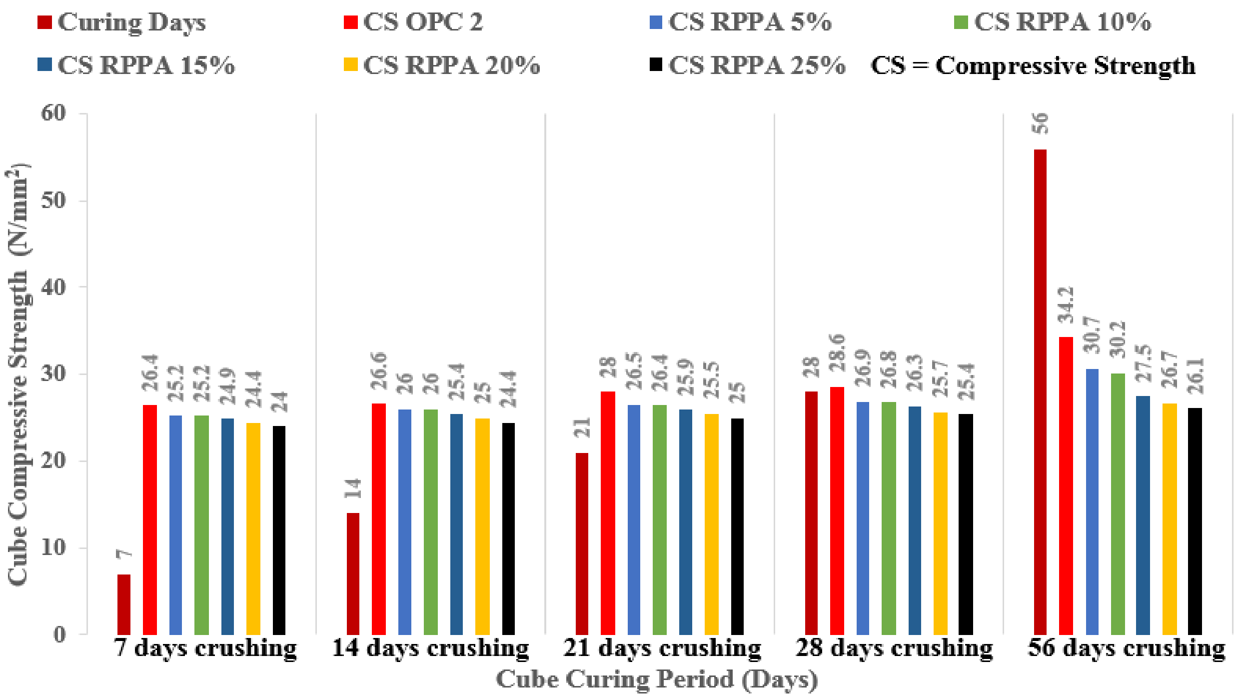

Figure 2: Mean Compressive Strength of RPPA Concrete over Curing Periods

Table 6: Mean Compressive Strength of URPPA in Concrete Cubes (N/mm^2)

Samples Curing Periods (days)	**100% OPC 2** Mean Compressive Strength N/mm^2	**5%** URPPA Mean Compressive Strength N/mm^2	**10%** URPPA Mean Compressive Strength N/mm^2	15% URPPA Mean Compressive Strength N/mm^2	**20%** URPPA Mean Compressive Strength N/mm^2	**25%** URPPA Mean Compressive Strength N/mm^2
7	26.84	26.46	25.46	25.00	24.81	24.44
14	27.13	26.94	26.65	25.71	25.38	24.77
21	28.56	27.72	26.89	26.04	25.84	25.40
28	29.22	28.79	27.56	27.00	26.09	25.79
56	34.97	34.27	31.45	27.69	26.93	26.58

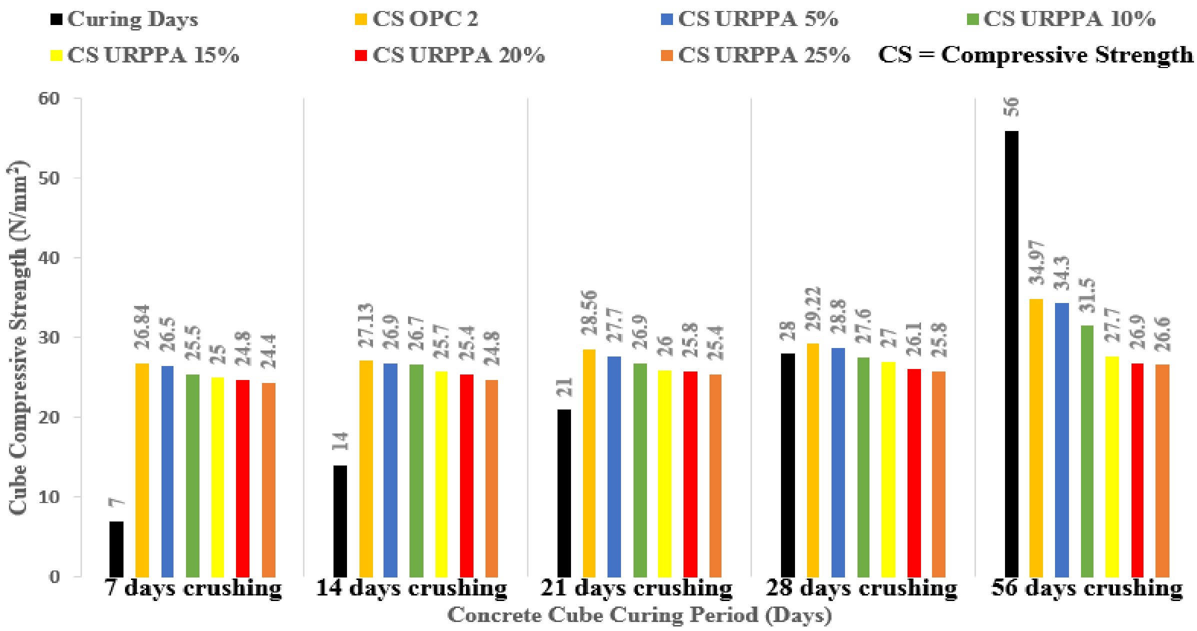

Figure 3: Mean Compressive Strength of URPPA Concrete over Curing Periods

The average compressive strengths of concrete cubes produced from RPPA and URPPA across the row, clearly presents a continuous decrease in crushing strength of the cubes with increasing partial substitution levels of RPPA at 5, 10, 15, 20 and 25% taking 56 days results for instance to be 34.97, 34.22, 30.73, 27.25, 26.66 and 26.14 (N/mm^2) *table 5* above. While for URPPA *table 6* above, has a result values taking for 56 days to be 34.97, 34.27, 31.45, 27.69, 26.93 and 26.58 (N/mm^2) respectively.

Similarly, analyzing the compressive strength of the specimen (RPPA and URPPA) cubes for the numbers of days being cured, (7, 14, 21, 28 and 56 days), it can be deduced from both *table 5* and *table 6,* going down the columns in the tables, the respective cube strengths increases with continuous increased in the specimen cube curing periods for both RPPA and URPPA, but apparently decreases with the increasing volume of RPPA and URPPA in OPC as follows; 5% RPPA substitution in OPC from 7 to 56 day down the columns are 26.41, 26.59, 27.90, 28.59 and 34.22 (N/mm^2) and for URPPA are similarly, 26.46, 26.94, 27.72, 28.79 and 34.27 (N/mm^2) respectively.

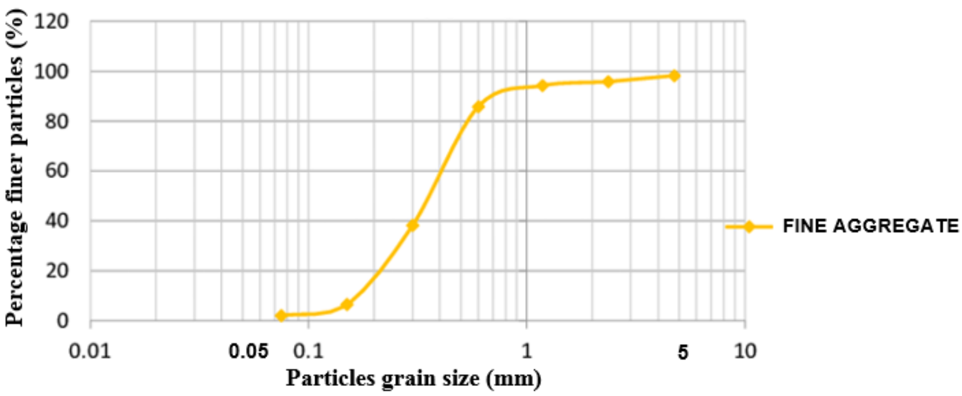

Figure 4: Plotting of particle size distribution of fine aggregate used

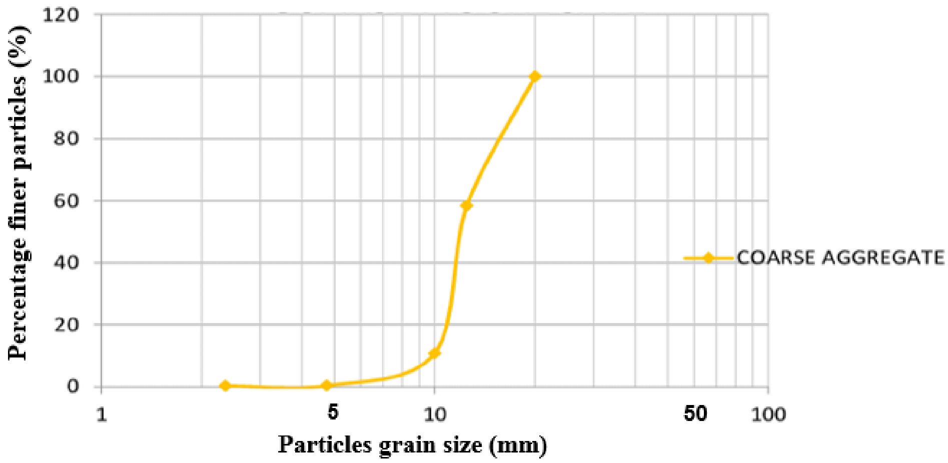

Figure 5: Plotting of particle size distribution of coarse aggregate used

4.4 Grain Size Analysis of Aggregates for RPPA and URPPA Cubes

Production of concretes can't be achieved in the presence of cement without the additions of either or both of fine and or coarse aggregates [soft sand, river/sharp sand, crushed rock (gravel and or quarry dust)] among other majors. Therefore in accordance with the standard methods of testing requirement (ASTM-C618 Class N), was used as a guide to evaluating the efficacies of both the river sand and gravel aggregates used herein, and presents the following results as in *figure 4* and *figure 5* as drawn. The plotting of points which produced a perfectly drawn orgive curves in both cases (*figure 4* and *5*), depicts the characteristics of the suitability of the aggregates used, with the proportion of higher percentage aggregate retained on sets of sieve over lesser percentage of finer retained on the sieve pan after vigorous sieving process via sieve sets having 150µm. Hence the aggregates possesses suitable characteristics of grains sizes distributions as indicated by the plotting of results obtained, during sieve analysis of the respective aggregates used in above.

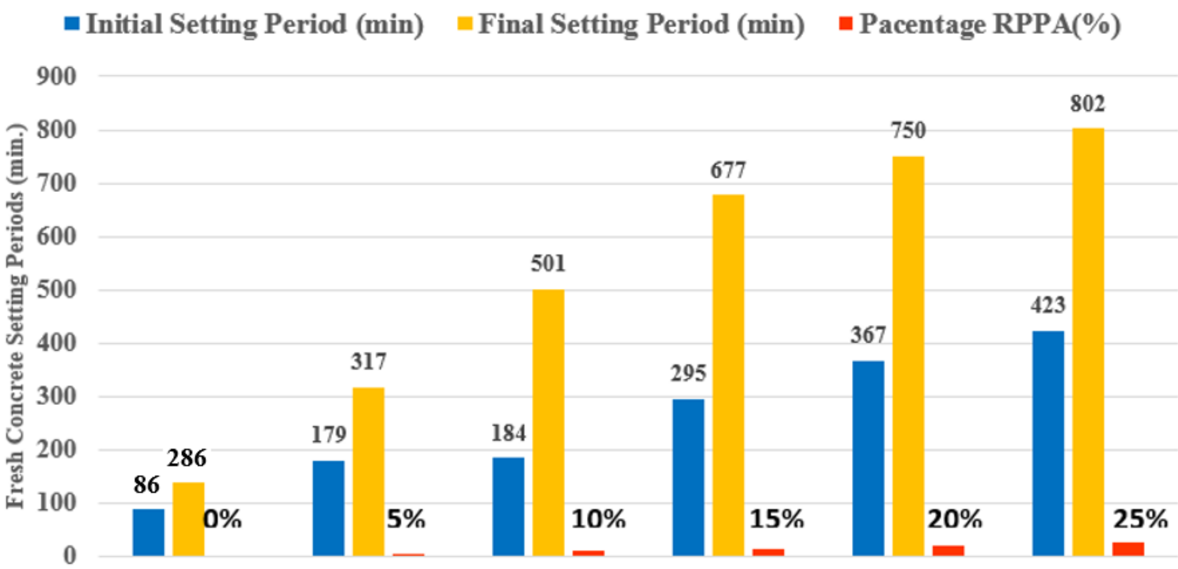

Figure 6: Percentage (%) RPPA Replaced through Fresh Concrete Mixes

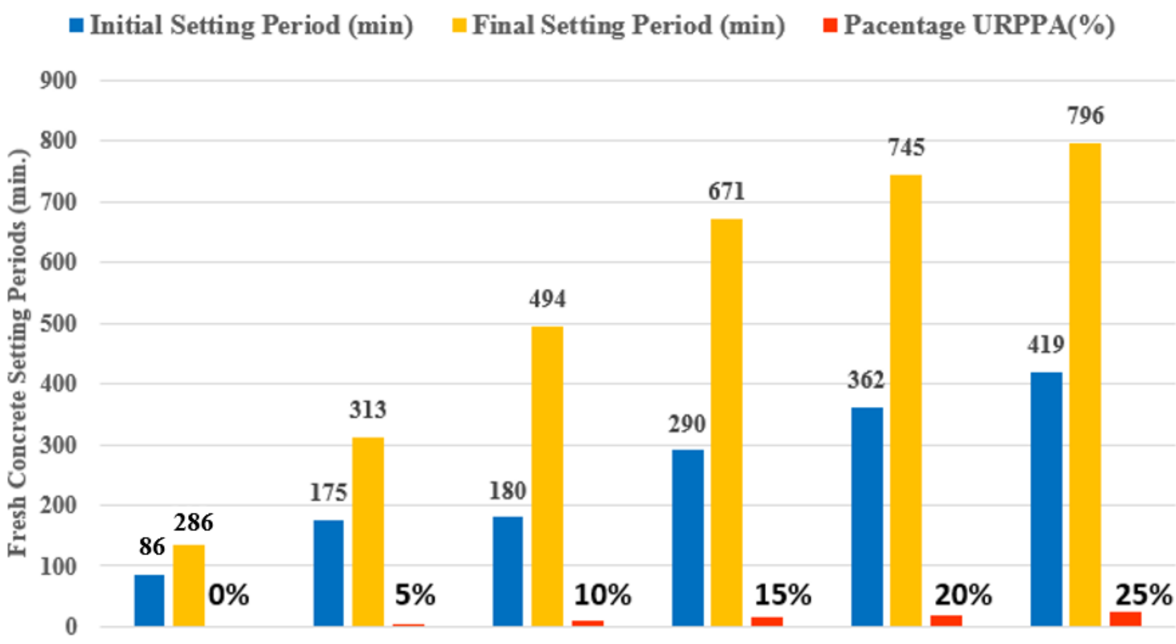

Figure 7: Percentage (%) URPPA Replaced through Fresh Concrete Mixes

4.5 RPPA and URPPA Concrete Setting Time(s)

In respect to the results obtained as in *figure 6* and *figure 7* above, it can be drawn from these observations that, both the concretes characteristic setting periods (initial and final) were simultaneously on the increased. However, these exceeds that of the controlled OPC with the initial setting period to be 86 minutes while the final period was recorded to be 286 minutes. However standard specification provides 65 and 275 minutes of both initial and final setting periods for fresh concrete mix. The contributory factor which most have led to a higher initials and final setting periods of both RPPA and URPPA concretes, are as a results of the increasing percentages of both RPPA and URPPA in OPC as clearly depicted in the above figures. So also, other contributing factor includes the exothermically reaction that exist in the presence of, when water is added onto cement, will liberates heat and creates an evapotranspiration process from fresh concretes. Similarly, the recorded setting time of RPPA concrete exceed that of the setting time of URPPA concretes in all proportional levels of percentage substitution (5, 10, 20 and 25%) in OPC.

5.0 Conclusion

This research work can be concluded by saying neither of RPPA nor URPPA from the chemical analysis is said to be acidic in nature, as confirmed from chemical examination of OPC, RPPA and URPPA *table 2*. Hence, it can be stated that both specimens has one of the effective component with the probability of being an effective supplementary admixture material for structural applications in the built environment.

However, it can be referenced herein that; an increased in the substitution of RPPA and URPPA in OPC, increases the average slump value of the overall concrete mixes. Similarly, the setting time of RPPA concrete exceed that of the setting time of URPPA concretes in all proportional levels of percentage replacements (5, 10, 20 and 25%) in OPC. These also contributed to an overall increased setting time of the RPPA and URPPA concretes in comparession to the controlled OPC concretes. Moreover, it can be stated that the contributory factor which most have led to a higher initials and final setting periods of both RPPA and URPPA concretes, are as a results of the increasing percentages of both RPPA

and URPPA in OPC. Other factors are the exothermical reactivity that exist in the presence of water when added onto cement, which liberates heat and creates an evapotranspiration process from fresh concretes.
Furthermore, there were variances in the compressive strength of URPPA when compared with that of the OPC at 7, 14, 21, 28 and 56 curing days, these exhibits; 10.58, 10.25, 12.43, 13.14 and 25.25% and similarly for URPPA when compared with that of the OPC at 7, 14, 21, 28 and 56 curing days it produces, 8.94, 8.70, 11.06, 11.88 and 23.99% respectively. Therefore, it can be said that the longer the period of concrete curing, the greater the compressive strength will be achieved in the presence of humid environment with simultaneous hydration of the concrete. Hence, in line with this research findings, URPPA concrete presents most effective compressive strength of the concrete results, than that of the RPPA, as it's evident in *table 5,6 and figure 2 and 3* respectively.
Therefore, it can also be summarized that the density of the specimens (RPPA and URPPA) decreases with increasing volumes of RPPA and URPPA in OPC, but the overall density requirements fall within the allowable spelt standard of 2200 to 2600 kg/m^3. Therefore, RPPA and URPPA concretes in this case are classified to be normal weight concretes. Whereas RPPA and URPPA cubes densities increases with increasing cube curing period's i.e 7, 14, 21, 28 and 56 days respectively. This implies that, the more curing period of specimen cubes increased or are allowed, then the greater the density of the specimen cubes will be achieved for optimal performances.
Finally, compiling the various analytical attributes herein this research, it can be stated that URPPA has proven to be much effective supplementary material to be used for partial replacement in cement for structural development within the contemporary built environment rather than URPPA.

6.0 Recommendation

In line with the findings in this research work, it can further be recommended that:

a) It will be sustainable, as well as an economical viable means for which several nations can drastically reduce their dependability on the volumes of finite resources used for the production of cement. Hence the application of RPPA and URPPA in the built environment should be holistically encouraged,
b) Similarly, the plantation of plantain trees in large and small scales should be reinvigorated for environmental sustainability to increasing raw materials sources and to reducing soil erosion among other majors,
c) Its hereby recommended that RPPA and URPPA concretes should be used in the built environment as external and internal finishers for possessing suitable admixture characteristics,
d) Similarly, it's recommended that when there is the need to achieving late strength growth in concretes and or when effective hydrations of higher cementitious concrete mix is needed with little water requirement (binder) ratio during construction processes, then the utilisation of RPPA and URPPA will be highly effective as retarding admixtures.
e) Finally, it's recommended for further Research and Developments to explore 90 to 96 days periods of curing RPPA and URPPA concretes, so as to evaluate and exploit the immense benefits that comes with RPPA and URPPA concretes.

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