Abstract- Plantain (Musa paradisiaca) peels are by-product of plantain fruits, constituting about 40% of the fruits. Performance effects of Ripe Plantain peel ash (RPPA) and Unripe Plantain peel ash (UPPA) in concrete were investigated in this research. Both RPPA and UPPA were added to the concrete as admixture in the proportion of 1.5% and 2.5%. The percentage composition of Silica (SiO₂) and Alumina (Al₂O₃) contents in RPPA and UPPA were determined using spectrometry method of analysis. Slump test on the fresh concrete and compressive strength test were carried out on the concrete cube for 7, 14, 28, 56 and 90 days. The Silica (SiO₂) content for RPPA and UPPA were 46.37% and 54.00% respectively while the Alumina (Al₂O₃) content for RPPA and UPPA were 2.20% and 3.08% respectively. The compressive strength for the control mix at 28-day is 20.4N/mm², while that of 1.5 and 2.5% RPPA are 16.3 and 14.0N/mm² respectively representing decrease of 20.15 and 31.58% respectively, compressive strength results for concrete containing 1.5 and 2.5% UPPA are 14.4 and 12.2N/mm² respectively representing decrease of 29.32 and 40.01% respectively with the control mix. At later age, the strength development is observed to be on the increase with concrete containing admixtures. At 90-day, control sample has strength of 23.32N/mm² which is about 12.56% higher than 28-day strength, concrete with 1.5 and 2.5% RPPA have strength of 22.77N/mm² (28.50% increase), 20.64N/mm² (32.40% increase) respectively while 1.5 and 2.5% UPPA concrete have strength of 20.86N/mm² (31.00% increase) and 19.02N/mm² (35.70% increase).

Keywords- Admixture, Compressive strength, Ripe plantain peel, Unripe plantain peel, Workability.

1 INTRODUCTION

Concrete is a composite material which is made up of a filler and a binder, the cement paste which serves as a binder glues the filler together to form a synthetic conglomerate. Concrete workability is a property that directly impacts strength, quality, appearance, and even the cost of labour for placement and finishing operations. The strength of hardened concrete is measured by the compression test, the compressive strength of concrete is a measure of the concrete’s ability to resist loads which tend to compress it. Admixtures are the substances that are added in the concrete in addition to its ingredients to enhance its performance. The use of admixture in concrete is found in many ancient civilizations. Admixture, ranging from addition of chemical, are substances introduced in the concrete mixes in order to alter or improve the properties of the fresh or hardened concrete or both (Jackson & Dhir, 1996). Plantain belongs to the family Musa Ceae, Genus Musa originated in south East Asia area between Indian and Papua (Inusa, 2007). The plantain is a free-like herb perennial but mono-corpic, from two to six metres high, with milky juice in all part.

Plantain has been more importantly utilized as foods over the years, the fruits are either eaten raw or processed as foods and raw material for industrial purposes (Morton, 1987). The peels are well known for animal feeds due to their high moisture content, sources of fibres. In some African countries like Kenya and Uganda, they serve as raw materials and source of binder for briquettes (a fuel resource made from any agro-industrial wastes that can be recycled for cooking or heating) as reported by Megan (2007), little is known about the exploitation and application of their natural resins present in peels.

According to Mantell (1942) and Harborne (1984), resins from plants are known for their binding characteristics. Their ready availability is also a concern and crucial factor, especially in Nigeria where plantain peels products are cheap and readily available, they can be used in various forms as admixtures that would produce a better qualities in concrete production. There are types of admixtures available for use depending on the property requirements, they include: accelerators, retarders, air-entraining agents, water reducers or plasticizers, pigments, pozzolanas, pore fillers and super plasticizers (Neville, 2003).

Vasumathi et al (2003), experimentally investigated the properties of concrete when cement is replaced by fly ash and sand by quarry dust separately and simultaneously. Tests were conducted on workability at fresh state and compressive strength at hardened state at the age of 7, 14 and 28 days. The sand was replaced from 0 to 25% at increment of 5%. From the test results it was observed that workability was decreased due to addition of quarry dust. Better result on 28 days compressive strength was obtained on replacement of fly ash, quarry dust, fly ash and quarry dust at 5%, 15% and 10% respectively. It was concluded that replacement of cement with fly ash and sand with quarry dust resulted economical construction and also a solution for reducing the environmental pollution.

Retarders as the name implies, delay the beginning of the setting and hardening of concrete, they are most useful in hot countries where concrete has to be transported for some distances, and for concreting in large quantities in the hot weather, when it is important to avoid the formation of cold joints (Dhir, 1998). Rodway and Fedirko (1989), tested five different fly ashes covering a wide range of lime contents, which were used as 25% replacement in concrete mixtures. It was found that regardless of the lime content of the fly
ash, satisfactory air void size and spacing values could be obtained to produce durable fly ash concrete. In the research work, Obilade (2014), reported on the properties of Rice Husk Ash (RHA) when used as partial replacement for Ordinary Portland Cement (OPC) in concrete. OPC was replaced with RHA by weight at 0%, 5%, 10%, 15%, 20% and 25%. 0% replacement served as the control. Compacting factor test was carried out on fresh concrete while compressive strength test was carried out on hardened 150mm concrete cubes after 7, 14 and 28 days curing in water. The results revealed that the compacting factor decreased as the percentage replacement of OPC with RHA increased. The compressive strength of the hardened concrete also decreased with increasing OPC replacement with RHA.

2 MATERIALS

The ripe and unripe plantain peels used in this study were collected at different plantain processing centres in Ikole Ekiti, Ekiti State, Nigeria. The selection of cement used involved the exact knowledge of the connection between cement and performance required and, in particular, between kind of cement and either strength or durability or both the properties of concrete (Lea, 1970). Type II Ordinary Portland cements, which can provide sufficient levels of strength and durability, and the most common cements used by concrete users was used with brand name “Elephant”. Natural sand is the fine aggregate chiefly used in concrete mix. Sand may be obtained from sea, river, lake, etc, but when used in a concrete mix, it should be properly washed and tested to ascertain that it is free from clay, silt, and such organic matters. Fine aggregate used was river sand while crushed granite of maximum nominal particle size of 20 mm was used as coarse aggregate. The grading for the aggregates was done according to BS 1377 Parts 1 and 2 (1990). The uniformity coefficient (Cu) for the sand and granite were 5.4 and 5 respectively while their coefficients of curvature (Cc) were 1.36 and 1.0 respectively. Potable water was used in producing the concrete mixture.

3 EXPERIMENTAL METHODOLOGY

The plantain peels (ripe and unripe) were burnt to ash in a furnace at 700°C temperature for 90 minutes Describe the incinerator used. The ash product was sieved, using 150 μm sieve size to produce fine ash. The chemical analysis tests were performed on the ash to determine the level of their chemical compositions. The chemical composition of natural pozzolan is stated as 50–67% SiO₂ in the German standards (DIN 51043).

3.1 MIX PROPORTION

The concrete investigated was of grade M15 with mix ratio 1:2:4 and water-cement ratio of 0.7. What informed the value 0.7 chosen? The RPPA and UPPA ash was added at 0%, 1.5%, and 2.5% by weight as admixture and mixed with cement, fine and coarse aggregates. The concrete mix batching was done by weight.

3.2 TEST PROCEDURES

The slump test is a means of assessing the consistency of fresh concrete. It is used, indirectly, as a means of checking that the correct amount of water has been added to the mix. The test was carried out in accordance with BS EN 12350-2 (2009). The test is popular due to the simplicity of apparatus used and its simple procedures.

Concrete cubes of sizes 150 x 150 x 150 mm were prepared using predetermined constant optimum water binder ratio (w/b) of 0.70 with 1.5% and 2.5% RPPA and UPPA as concrete admixtures. 3 No cubes for each concrete mix were cast and cured for 7, 14, 28, 56, and 90 days. Prior to crushing, the specimens were removed at each curing age, weighed and were later tested using compression machine. Average of three readings was determined and noted.

4 RESULTS AND DISCUSSION

4.1 CHEMICAL COMPOSITION

The results of the chemical composition analysis of the RPPA and UPPA are listed in Table 1. Indicate the source for % portland cement in the last column. RPPA contained lesser amount of all the chemicals present in the admixture material used. A relatively low content of SiO₂ + Al₂O₃ could also indicate the acidic nature of the admixture material. The concept had been shown that the most important composition of admixture is SiO₂ and it can provide contributions to pozzolanic activity in non-crystalline form (Alp et al, 2009). The chemical composition of natural pozzolan is stated as 50–67% SiO₂ in the German standards DIN 51043 (1979).
Table 2. Effect of RPPA and UPPA on workability of Concrete (slump test)

| Proportion (%) | Control (0%) | UPPA (1.5%) | UPPA (2.5%) | RPPA (1.5%) | RPPA (2.5%) |
|----------------|--------------|-------------|-------------|-------------|-------------|
| Slump Value (mm) | 20 | 25 | 26 | 24 | 26 |

4.3 DENSITY OF CONCRETE SPECIMENS

Table 3 showed the mean density recorded by each concrete proportion, the range and standard deviation. The density of the specimens ranged from 2251.85 to 2488.88 Kg/m³. This lies within the range of 2200 to 2600 Kg/m³ specified as the density of normal weight concrete (Falade et al, 2010). The control mix produced concrete specimen with the highest mean density of 2445.44 Kg/m³, followed by 2.5% of both RPPA and UPPA admixtures with mean values of 2414.13 Kg/m³ and 2389.31 Kg/m³ respectively. UPPA admixture at 1.5% had the mean density of 2383.82 Kg/m³ while admixture of RPPA at 1.5% produced the lowest mean density at 2336.84 Kg/m³.

The strength of the specimens continually increased during the 28 days of curing as water, which allows continuous cement hydration was present in abundance thereby ensuring 100% relative humidity. This result is similar to those obtained by Raheem and Aderounmu (2002), Adesanya and Raheem (2002) and Raheem and Abimbola (2006). At later age, 56 days and 90 days, the strength development is observed to be on the increase with concrete containing admixtures compared to the normal concrete. At 90-day, normal concrete has strength of 23.32 N/mm² which is about 12.56% higher than 28-day strength. Nevertheless, concrete with 1.5 and 2.5% RRPA have strength of 22.77 N/mm² (28.50% increase), and 20.64 N/mm² (32.40% increase) respectively while 1.5 and 2.5% UPPA concrete have strength of 20.86 N/mm² (31.00% increase) and 19.02 N/mm² (35.70% increase).

5 CONCLUSION

Based on the findings of this study, the following five conclusions were drawn;

1. The workability of concrete increases due to the addition of both Ripe Plantain Peel Ash (RPPA) and Unripe Plantain Peel Ash (UPPA).
2. Ripe Plantain Peel Ash (RPPA) contained lesser percentage of Silica (SiO₂) and Alumina (Al₂O₃) compared to Unripe Plantain Peel Ash (UPPA).

Table 3. Density of concrete with different proportion at various ages

| Concrete proportion | Curing period (days) | Density (Kg/m³) | Mean (Kg/m³) | Range (Kg/m³) | Standard Deviation |
|---------------------|----------------------|-----------------|--------------|---------------|-------------------|
| Control mix         | 7                    | 2488.88         | 2445.44      | 74.07         | 26.92             |
|                     | 14                   | 2444.44         |              |               |                   |
|                     | 28                   | 2414.81         |              |               |                   |
|                     | 56                   | 2438.52         |              |               |                   |
|                     | 90                   | 2440.56         |              |               |                   |
| RPPA 1.5%           | 7                    | 2251.85         |              |               |                   |
|                     | 14                   | 2251.85         |              |               |                   |
|                     | 28                   | 2355.65         |              | 236.84        | 157.04            |
|                     | 56                   | 2370.37         |              | 237.82        | 88.89             |
|                     | 90                   | 2432.04         |              | 2438.52       | 35.09             |
| RPPA 2.5%           | 7                    | 2444.44         |              |               |                   |
|                     | 14                   | 2408.89         |              |               |                   |
|                     | 28                   | 2336.84         |              | 2414.13       | 88.79             |
|                     | 56                   | 2429.63         |              | 2370.37       | 33.04             |
|                     | 90                   | 2432.04         |              | 2438.52       | 35.09             |
| UPPA 1.5%           | 7                    | 2260.74         |              |               |                   |
|                     | 14                   | 2423.70         |              |               |                   |
|                     | 28                   | 2394.07         |              | 2383.82       | 177.70            |
|                     | 56                   | 2429.63         |              | 2370.37       | 73.78             |
|                     | 90                   | 2438.44         |              | 2438.52       |                   |

3. The density of concrete with different proportion of RPPA and UPPA ranges between densities of 2251 and 2488 Kg/m³ and are classified as a normal weight concrete and this helps in the optimization of concrete density to improve structural efficiency (the strength to density ratio), reduce transportation costs, and also enhance the hydration of high-cementitious concrete mixtures with low water-binder ratios.

4. There were significant differences in the compressive strengths of both RPPA and UPPA compared with the control mix at the first 28-day age. Nevertheless, the compressive strength at later age, 56 and 90 days were compared well with the normal concrete. It showed that RPPA and UPPA admixtures appear to contribute to late strength development of concrete.

5. At both 1.5% and 2.5% proportions, the compressive strength at 28 and 90 days of RPPA are higher than that of UPPA. It indicated that the lesser percentage of both Silica and Alumina in RPPA have helped in better compressive strength over UPPA.
Fig. 1: Compressive strength of concrete specimens

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