# INVESTIGATION INTO THE USE OF PLANTAIN PEELS ASH AS ADMIXTURE IN CONCRETE PRODUCTION

*Dyuran, D.I. Aguwa, J.I and Kolo, S.S*

Dyuran, D.I,
Department of Civil Engineering, Federal University of Technology, Minna
Email: dyuran4@gmail.com
+234-703-650-1098

Aguwa, J.I*
Department of Civil Engineering, Federal University of Technology, Minna
Email: jiaguwa@yahoo.com
+234-803-316-3634

Kolo, S.S*
Department of Civil Engineering, Federal University of Technology, Minna
Email: s.kolo@futminna.edu.ng
+234-803-687-9855

**Paper No [***for official use only]*

## ABSTRACT

*This research was carried out to examine the possibility of using Plantain Peels Ash (PPA) as admixture in concrete production. The plantain Peels were sourced locally and were carefully processed (washed, dried, burnt and grinded) into Ash. The powder form of the plantain peels* *was sieved through a 45µm BS sieve. All of these requirements for Admixture materials were met. It was observed that the slump value and the workability of the concrete decreased as the percentage of PPA was increased this is because of high specific surface area of PPA which increases water demand thereby decreasing the slump value and workability of the concrete. It was observed that the percentage of water absorbed by the concrete cubes decreased as the percentage of PPA increased. It was concluded that PPA increased by 23% the compressive strength of the concrete cubes along the ages of curing as the percentage of PPA was increased. However the compressive strength decreased by 7.2% at the early ages of curing (7days and 14days) as the percentage of PPA increases. While it also increased by 9% at the later ages of (21 and 28 days). PPA can be used as a set retarding admixture since it was able to reduce the amount of bleeding water of the concrete and PPA can be used as set retarding admixture in concrete since it was able to reduce the setting time of the concrete to which it was added.*

**Keywords**: Admixture, Cement, Concrete, Plantain Peels Ash and Set Retarding

## INTRODUCTION

Concrete is a composite construction material, which is composed of cement (commonly Ordinary Portland Cement (OPC)), aggregates (coarse and fine aggregate), water, and in some cases admixtures. Material Scientists, Chemists, Engineers, and manufacturers' technical representatives have helped the concrete industry to improve the ability to control concrete setting time, workability, water/cement ratio, compressive strength, and durability of concrete by adding some supplementary substances named admixtures (Anitha, 2016).

Admixtures for use in concrete are defined in BS EN 206– 1 as " material added during the mixing process of concrete in small quantities related to the mass of cement (usually within the range of 0.2% to 5% of the mass of concrete) to modify the properties in the fresh or hardened state" . Admixtures are now widely accepted as materials that contribute to the production of durable and cost-effective concrete structures. The contributions include improving the handling properties of fresh concrete, making placing and compaction easier, reducing the permeability of hardened concrete and providing freeze/thaw resistance (Trif, 2014)

The function of each admixture focuses on a specific need, and each has been developed independent of the others. Some admixtures already have chemistry that affects more than one property of concrete, and some have simply been combined for ease of addition during the batching process. Admixture is an essential component of any modern concrete mix, providing a compromise for the conflict between water and workability and performance of hardened concrete. The advancement in admixture technology has played a significant role in the development of concrete technologies.

Grace (1999) carried out a research on Advanced admixture applications in high performance concrete infrastructure construction and obtained a result that with the powerful dispersion capability and flexibility in molecular design, Polycarboxylic Acid- admixtures enable the production of concrete at low water cementitious ratio with high workability, use of more blending materials, and to cater to different challenging requirements, such as high strength, high durability, high workability and long workability retention.

According to Woolley and Conlin (1989), use of Fly ash as admixture is effective in reducing heat of hydration. Compressive strength as well as other structural properties of concrete, depends on the degree to which cement hydrates.

Modak *et al* (2012) evaluated how different contents of Rice Husk Ash (RHA) added to concrete may influence its physical and mechanical properties. Sample Cubes were tested with different percentage of RHA and different water/cement ratio, replacing in mass the cement. Properties like Compressive strength, Water absorption and Slump retention were evaluated. the result showed that RHA concrete can be effectively used as light weight concrete for the construction of structures where the weight of structure is of supreme importance.

## METHODOLOGY

### Materials

**Cement:** The Cement for that was used for this research work is Ordinary Portland Cement. It was sourced locally from Dangote Cement product, Nigeria. It conformed to the requirements of (BS EN 197-1: 2000) 35kg of cement were brought to the Federal University of Technology, Minna Civil Engineering laboratory where the research was carried out.

**Fine Aggregate:** The sand intended for this research work was also locally sourced from Ferin Doky, Minna, Nigeria. The impurities were completely removed in accordance to the requirements of BS 882 (1992). 10 Tones of the aggregates were brought to the Federal University of Technology, Minna Civil Engineering laboratory where the research was carried out.

**Coarse Aggregate:** The granite used for this research work is within the range of 5-20mm in diameter; It was sourced locally from Tricta quarry in Minna, Nigeria and it conforms to requirements of BS 882 (1992).

**Plantain Peel Ash (PPA):** The plantain peels used for this research were sourced locally from Zuba fruit market, Abuja. The ripe plantains were peeled and air-dried. The dried sample was burnt in open air to ash, the ash sample was sieved through a 150µm sieve, in accordance to the American Society for Testing Methods (ASTM-C618 Class N).

Potable water was used for this research**,** the water was obtained from Federal University of Technology, Minna municipal water supply, It conformed to BS EN 1008 (2002) requirements.

**Methods**

The following methods were used in this research, all the tests were carried out at the Civil Engineering laboratory of Federal University of Technology, Minna, Nigeria except otherwise stated.

i. Chemical composition of PPA: The chemical analysis of the PPA was carried in the department of Chemistry at Ahmadu Bello University, Zaria.
ii. Particle size distribution test, this was carried out in conformity to BS 1377-2:1990.
iii. Bulk density
iv. Specific gravity.
v. Concrete Mix Design: The British (Department of Environment, DOE) method of concrete mix design was used for this research to obtain the mix proportion of 1:$1\frac{1}{2}$ : 3.
vi. Setting time test; The method of penetration resistance (ASTM C403) was used to determine the setting of the concrete to which PPA was added.
vii. The Compressive Strength Test: The test was carried out on the concrete cubes using the Crushing Machine at the Civil Engineering laboratory of Federal University of Technology, Minna. This was done in accordance with BS 1881: Part 116 (1983).

## RESULTS AND DISCUSSION

### Chemical Analysis of PPA

The chemical analysis of the PPA was carried out at the Department of Chemistry, Ahmadu Bello University, Zaria. The result of the chemical composition is presented in Table 1. The chemical compound of Silicon dioxide (SiO = 79.38%), Iron oxide ($Fe_2O_3$= 6.53%) and Aluminum oxide ($Al_2O_3$= 19.84%) which constitute a total sum of 105.37% of pozzolanic materials. The value obtained exceeds the minimum value of 70% requirement for a material which possesses pozzolanic properties according to (ASTM C 618 part 78, 1978). The value (79.38% ) obtained is greater than the value obtained by Ijuta (2009) for Rice Husk Ash (48.36%), which is a clear indication that PPA is of high pozzolanicity and can be used as admixture in concrete production as compared to natural pozzolanas. Kayam (1995) who also carried out the same chemical analysis on PPA obtained a close value of 88.56% to the value obtained in this research.

From Table 1. It can be clearly seen that the percentage composition of $SiO_2$ in PPA is 79.31% which is three times greater than that of (OPC) 28.57%. According to Godwin *et al* (2014), Ash is said to have cementitious and reactive properties if the summation of CaO, $SiO_2$, $Al_2O_3$ and $Fe_2O_3$ is above the required minimum value of 70% as specified by (ASTM C 618 part 78).

Table 1: Chemical Composition of OPC and PPA

| Elemental Oxide | Percentage composition of OPC | Percentage Composition of PPA |
|---|---|---|
| $SiO_2$ | 28.57 | 79.38 |
| CaO | 79.12 | 1.08 |
| $Al_2O_3$ | 2.80 | 19.84 |
| MgO | - | 5.13 |
| $Fe_2O_3$ | 4. 28 | 6.53 |
| $Mn_2O_3$ | 0.01 | 0.34 |
| $K_2O$ | 0.24 | 2.62 |
| $P_2O_5$ | - | 9.08 |
| $SO_3$ | 1.6 | 0.00 |
| $TiO_2$ | 0.16 | 0.61 |
| ZnO | - | 0.00 |
| $Cr_2O_3$ | 0.038 | 0.00 |
| $Na_2O$ | - | 3.20 |

**Slump Value**

It was observed that the values for the workability and slump of the concrete decreased as the percentage of the PPA increased. It was also observed that there was a higher water demand as the percentage of PPA increased, that led to decrease in the slump values of the concrete as shown in Figure 1. The decrease in the slump value is as a result of high specific surface area of PPA which increases water demand thereby decreasing the slump of the concrete. This can be offset by adding effective Superplasticizer to the concrete to increase the slump value of the concrete (Tyap, 2007)

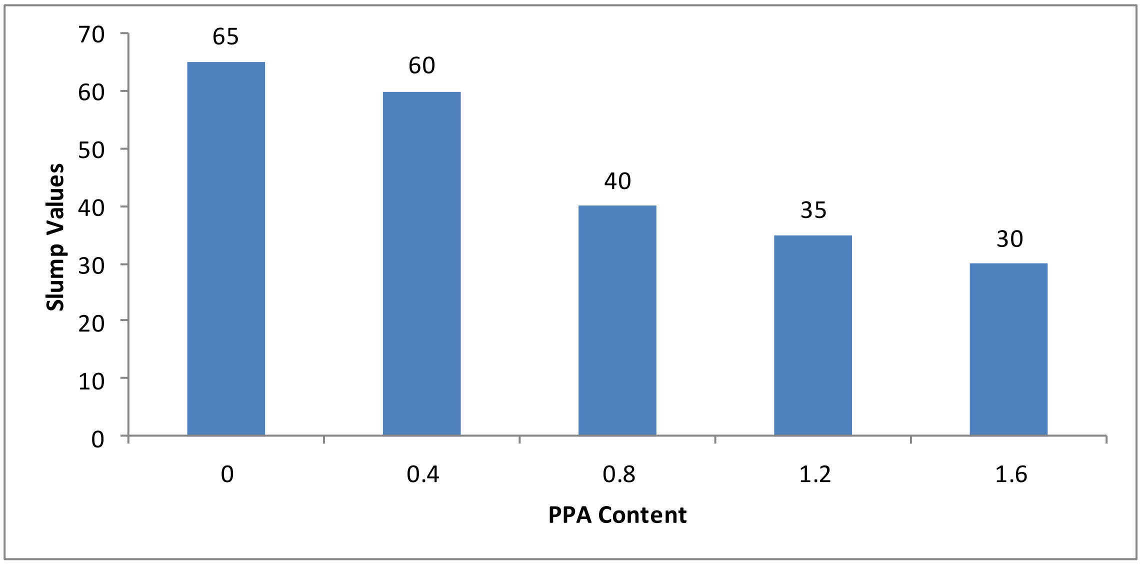


Figure 1: Relationship between Slump values and PPA Content.

## Compacting Factor

From Figure 2 it can be seen that there was a decrease in the compacting factor. The decrease in the workability is as a result of high specific surface area of PPA which increase water demand thereby decreasing the workability of the concrete. This can be offset by adding effective Superplasticizer to the concrete to increase the workability (Tyap, 2007)

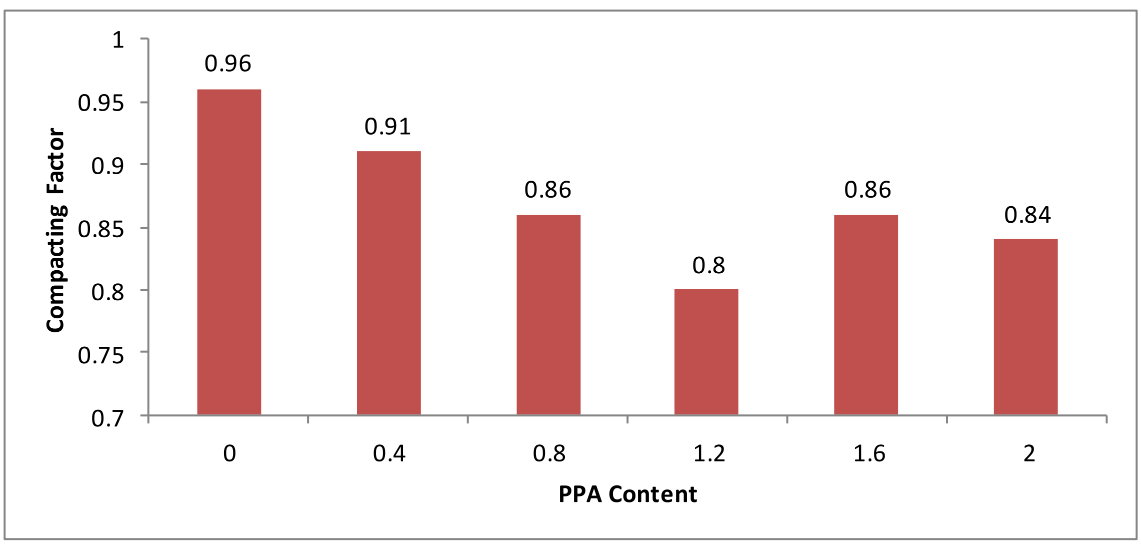


Figure 2: Relationship between Compacting Factor and PPA Content

**Setting Time**

It was observed that the initial and final setting times increased as the percentage of PPA used was increased. The result is shown in Figure 3. It was observed that the initial and final setting time of PPA were longer than that of Ordinary Portland cement paste which has an initial setting time of 87minutes and a final setting time of 165 minutes. This is because Tricalcium Silicate ($C_3S$) which gives the hardening and compressive strength of paste at early age in blended paste of PPA is reduced (Cheerarot, 2004). Moreover the reaction between cement and water is exothermic this leads to the liberation of heat and evaporation of moisture and consequently stiffening of the paste. As the quantity of PPA reduces, the reaction reduces and the quantity of heat liberated also reduces thus; leading to a late stiffening of the paste. As the hydration process requires water, greater amount of water was also required for the process to continue (Cheerarot, 2004).

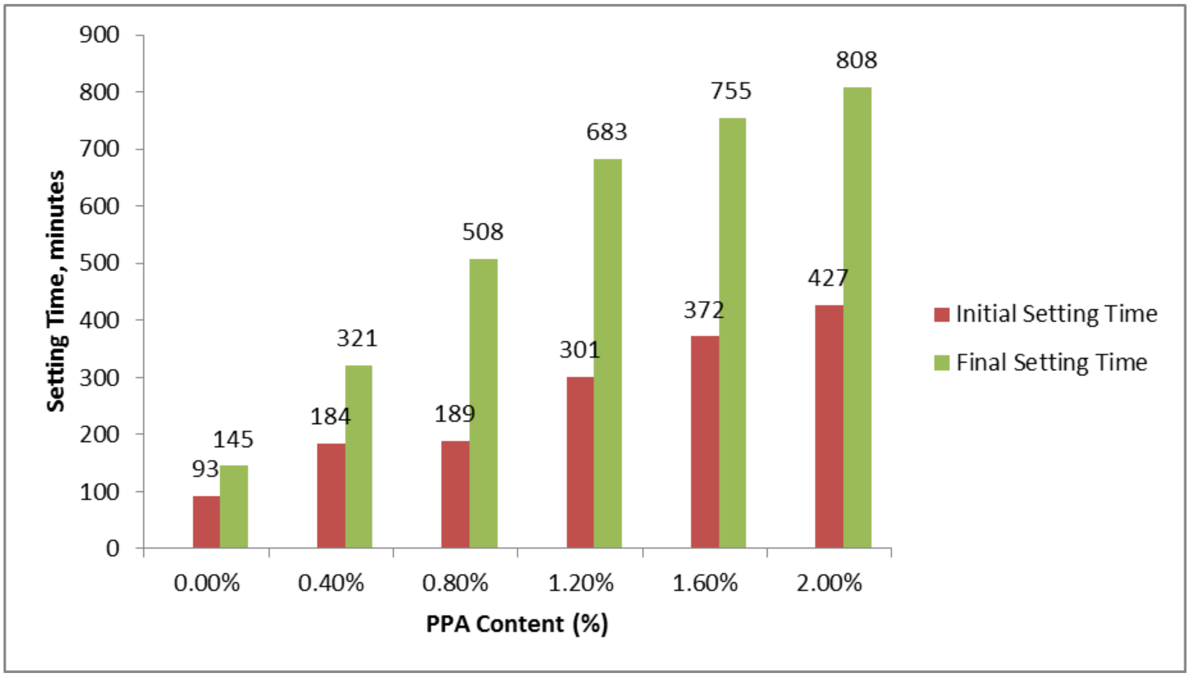


Figure 3: Relationship between Setting Time and PPA Content

**Compressive strength**

It was observed that the compressive strength of the concrete at day 7 and 14 decreased as the percentage of the PPA was added by an average of 1.7% of the characteristic strength as the percentage of the PPA was added. At a curing age of 21 days, It was observed that the compressive strength of the concrete cubes increased as the percentage of the admixture was increased up to 1.2% PPA, though the increment in compressive strength was not significant as the increased in strength was at an average of 9.2% It was also observed that the compressive strengths of the concrete cubes with PPA as admixture increases with curing age like normal concrete. The greater compressive strength was observed at a value of 1.2% the result of the compressive strength at day 28.

It was observed that the compressive strength of the concrete cubes actually increased at day 28 as the percentage of the PPA was increased. It was also observed that the compressive strengths of the concrete cubes with PPA as admixture like normal concrete increases with curing age. The greater compressive strength gain was observed at an optimum PPA value of 1.2%

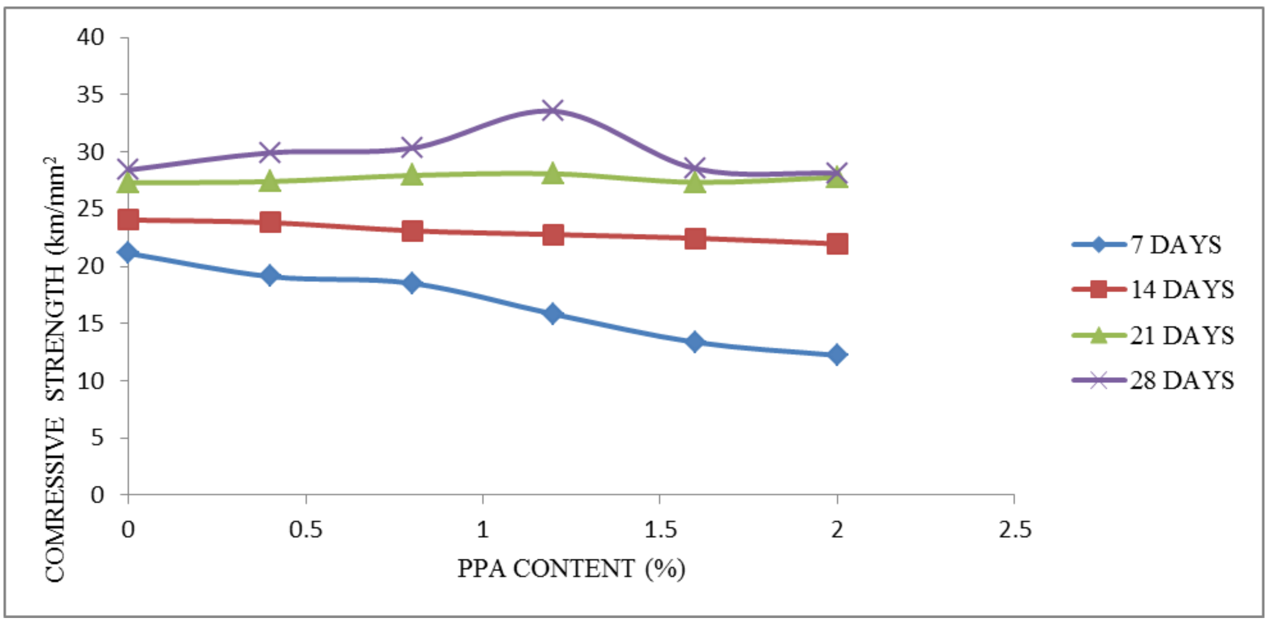


Figure 4: Relationship between compressive strength of concrete and PPA content

## CONCLUSION

### Conclusion

The following provides the summary of results obtained from this research. i. The chemical analysis of PPA was carried out and the result indicated that PPA met the requirements for admixture materials as specified by ASTM-C618

ii. PPA reduces the slump and workability of the concrete as the percentage of the PPA was increased.

iii. Increases the setting of concrete

iv. PPA decreases the compressive strength of concrete at the early age of curing as the percentage of PPA increases. However PPA increases the compressive strength of the concrete cubes as the percentage of PPA increases at the ages of 21days and 28days. PPA also increases the compressive strength of the concrete cubes along with the age of curing, though the increment was not significant .

### Recommendations

i. PPA is recommended to be used as set retarding admixture the concrete since it was able to increase the setting time of the concrete to which it was added.

**REFERENCES**

Anitha, J. L. (20016) “ Use of admixtures in concrete production” Reprinted from 8th International congress on the chemistry of cement. Vol. 1

Ado, S. (2016). Supplementary cementing materials in concrete: Part I: efficiency and design. Cem. Concr. Res., 32(10): 1525-1532

Arezoumandi M. and Volz, J. S. (2013) “ Effect of fl y ash replacement level on the fracture behavior of concrete,” Front. Struct. Civ. Eng, vol. 7, no. 4, pp. 411– 418,.

Arie, D. and Sagiv, S. (2005)“ The beauty of admixture” Volume 37 No.2.

Booya, E. (2012) “ Fresh properties of self-compacting cold bonded fly ash lightweight aggregate concrete with different mineral admixtures,” Mater. Struct., vol. 45, pp. 1849– 1859,.

British Standard Institution 1881: Part 116: (1983) “ Methods for determination of compressive strength of concrete” . Her majesty office, London.

British Standard Institution (1983). Methods for Determination of Compressive Strength of concrete cubes, BS 1881, Part 116, British Standard Institution, London.

British Standard Institution (1992). Specifications for aggregates from natural sources for concrete, BS 882, Part 2, British Standard Institution, London.

British Standard Institution (2000). Specification for Portland cement, BS EN 197-1, British Standard Institution. London.

Cheah, C.B. and Ramli,M. (2011). The implementation of wood waste ash as a partial cement replacement material in the production of structural grade concrete mortar: an overview Review Article, Resources, Conservation and Recycling. Vol. 55 Issue 1, pp 669-685.

Chopra, D. Siddique, R. and Kunal, B. (2011) “ Strength, permeability and microstructure of self-compacting concrete containing rice husk ash,” Biosyst. Eng., vol. 130, pp. 72– 80.

Conlin, M. (2010), “ Compatibility Issues between Cement and Chemical admixtures in concrete” The Indian concrete journal of concrete engineering, Delhi

Coutinbo, J.S. (2003).The Combined Benefits of CPF and RHA in Improving the Durability of Concrete Structures, Cement and Concrete Composites, Vol. 25, pp. 51-59.

Dahiru, A.A. and Ado, M. (2016),“ Investigation into the use of plantain Peel Ash as Admixture in concrete” IJESC 6(5) 5377 - 5380

Dhir, Y. (2015) “ Pore structure of concrete with mineral admixtures and its effect on self desecration shrinkage” . ACI Materials Journal. California.

Dewar, T. (1986) “ Construction chemicals” .Venu Malagavelli, International Journal of Engineering Science and Technology. Vol. 2(10), 2010, 5107-5113

Elinwa, A. U. and Ejeh, S. P. (2004), “ Effects of the incorporation of sawdust waste incineration fly ash in cement pastes and mortars” , Journal of Asian Architecture and Building Engineering, Vol. 3 No.1, pp.1-7.

Estensen, A., Kanstad, T., Bjøntegaard, O. and Sellevold, E. (2017) “ Cement and Concrete Research Comparison of tensile and compressive creep of fly ash concretes in the hardening phase,” Cem. Concr. Res., vol. 95, pp. 188– 194.

Feng, J., Liu, S. and Wang, Z. (2015 ) “ Effects of ultrafine fly ash on the properties of high-strength concrete,” J. Therm. Anal. Calorim., pp. 1213– 1223.

Gideon, O. (2014) “ Strength performance of a single type of Fly ash” Journal of Asian Architecture and Building Engineering, Vol. 2 No.13, pp.6-9.

Gulti, C.S., Roy, A. Metcalf, J.B. and Seals, R.K. (1996) “ The influence of admixtures on the strength and linear expansion of cement- stabilize phosphogypsum” .

Inusa L. (2007) “ Investigation into admixture properties of Plantain Peels Ash” Civil Engineering Department, Bayero University, Kano, Nigeria.

Ighodaro, D. (2012) “ Effect of Metakaolin Content on the Properties of High Strength Concrete,” Int. J. Concr. Struct. Mater., vol. 7, no. 3, pp. 215– 223.

Ramachandran, A., and Malhotra, K. (2014). Chemical composition of unripe and ripe plantain (*Musa paradisiaca). J. Sci food Agric* 24, 703-707

Kraus, H. T., Siewert, M., K. and Ludwig, H. M. (2015) " Effect of macro-mesoporous rice husk ash on rheological properties of mortar formulated from self-compacting high performance concrete," Constr. Build. Mater., vol. 80, pp. 225– 235,.

Muchendu, J. (2014) " Effect of macro-mesoporous rice husk ash on rheological properties of mortar formulated from self-compacting high performance concrete," Constr. Build. Mater., vol. 80, pp. 225– 235,.

Meddah, M. S, and Tangnit-Homas, Arezki, T (2009) " Pore structure of concrete with mineral admixtures and its effect on self-desecration shrinkage" . ACI Materials Journal. May 1 Friday.

Mihai P. and Bogdan Ros¸CA (2008) " Characteristics of concrete with admixtures" , Gheorghe asachi" technical university, jassy, Department of concrete, materials,technology and management.

Modaka, T., Jupta, R. and Deka, M. (2012) " Evaluation of the effect of different rice content ash on the physical and Mechanical properties of concrete" Wuhan Univ. Techno, pp. 765– 768.

Monk V. (1983) " Influence of cement composition and admixture dosage on properties of rapid-setting SCC for repair application- lessons learned" , Purdue university, school of civil engineering west Lafayette IN-47907

Muhammad K.R (2005): Investigation into chemical composition of plantain. M. Science Thesis. Chemistry Department Bayero University, Kano.

Muthadhi, A. and Kothandaraman, S. (2013) " Experimental Investigations of Performance Characteristics of Rice Husk Ash – Blended Concrete," J. Mater. Civ. Eng., vol. 25, no. August, pp. 1115– 1118.

Narattha, C., Thongsanitgarn, P. and Chaipanich, A. (2013) " Thermogravimetry analysis , compressive strength and thermal conductivity tests of non-autoclaved aerated Portland

Neville A.M. (2003) “ Properties of concrete” Fourth edition Pearson Education, Singapore.

Nochaiya, T., Wongkeo, W., Pimraksa, K. and Chaipanich, A. (2010) “ Microstructural , physical , and thermal analyses of Portland cement – fly ash – calcium hydroxide blended pastes,” J Therm Anal Calorim, pp. 101– 108.

Owens, O. J. (2013) “ Strength performance of a single type of Fly ash” Journal of Asian Architecture and Building Engineering, Vol. 2 No.13, pp.6-9.

Pilla, G and Menon, K. (2010) “ Characteristics of concrete with admixtures” , technical university, jassy, Department of concrete, materials, technology and management.

Peiwei, G. A. O., Xiaolin, L. U. and T. Mingshu, (2009) “ Shrinkage and Expansive Strain of Concrete with Fly Ash and Expansive Agent,” J. Wuhan Univ. Technol., vol. 24, no. 1, pp. 150– 153.

Ponmalar V. and Abraham, R. A. (2015) “ Study on effect of natural and ground Rice-Husk Ash concrete,” KSCE J. Civ. Eng., vol. 19, no. 6, pp. 1560– 1565.

Prashant V. Ram and Jan Olek. (2004) “ Influence of cement composition and admixture dosage on properties of rapid-setting SCC for repair application- lessons learned” , Purdue university, school of civil engineering west Lafayette IN-47907

Pyatip, C. (2009) “ Thermogravimetry analysis , compressive strength and thermal conductivity tests of non-autoclaved aerated Portland

Raheem, A. A.; Oyebisi, S. O.; Akintayo, S. O. and Oyeniran, M. I. (2010), “ Effects of admixtures on the properties of corn cob ash cement concrete” , Leonardo Electronic Journal of Practices and Technologies, Vol. 16, pp.13 – 20.

Ramasamy, V. (2012) “ Compressive strength and durability properties of Rice Husk Ash concrete,” KSCE J. Civ. Eng., vol. 16, no. 1, pp. 93– 102.

Sakr, K. (2006) “ Effects of Silica Fume and Rice Husk Ash on the Properties of Heavy Weight Concrete,” J. Mater. Civ. Engi- neering, vol. 18, no. June, pp. 367– 376.

Sensale, G. R. (2010) “ Cement & Concrete Composites Effect of rice-husk ash on durability of cementitious materials,” Cem. Concr. Compos., vol. 32, pp. 718– 725, Sereda, P.J., Feldman R.F. and V.S Ramachandran. (1980) " Influence of admixtures on the structure and strength development" . Reprinted from 7th International congress on the chemistry of cement. Vol. I, Paris p. VI-1/32-VI-1/44.

Srinvasan, A. and Sathiya, F. (2010) " Effect of Sugar Cane Bagasse Ash on the compressive strength of concrete" Cem. Concr. Compos., vol. 31, pp. 715– 728.

Takahiro, N. and Hiroshi, T. " Influence of admixture impurities on the crystal quality of inorganic phosphorous compound" .

Trif, K.T. (2014) " Effects of admixtures on the permeability of concrete" Wuhan Univ. Technol. -Mater. Sci. Ed, pp. 505– 523.

Turanli, L., Uzal, B., and Bektas, F. (2004) " Effect of Material Characteristics on the Properties of Blended Cements Containing High Volumes of Natural Pozzolans" ,Cement and Concrete Research, Vol. 34, pp. 2277-2282.

Upkpata, E., Wopla, G. and Tupita. N. (2012) " Investigation into the effect of Rice Husk Ash as a partial replacement of ordinary Portland cement on the structural properties of concrete" Cement and Concrete Research, Vol. 23, pp. 2244-2262.

Wang, W., Yuan, C. L, G. and Zhang, Y. (2017) " Effects of pore water saturation on the mechanical properties of fly ash concrete," Constr. Build. Mater., vol. 130, pp. 54– 63.

Waswa-Sabuni, B.; Syagga, P. M.; Dulo, S. O. and Kamau, G, N. (2002), " Rice Husk Ash Cement – An Alternative Pozzolana Cement for Kenyan Building Industry" , Journal of Civil Engineering, JKUAT, Vol. 8, pp. 13-26.

Wongkeo, W., Thongsanitgarn, P. Chindaprasirt, P. and Chaipanich, A. (2013) " Thermogravimetry of ternary cement blends," J Therm Anal Calorim, vol. 113, pp. 1079– 1090.

Woolley, A. W and Conlin, R. (2012) " Use of Fly ash as admixture" Cement and Concrete Research, Vol. 31, pp. 2255-2272.