Sub-Sahara African Academic Research Publications
September, 2021 Editions

JASD
Journal of African Sustainable Development
Vol.21, No.2, ISSN: 2115-4255

LOCUST BEANS WASTE ASH ALKALINE ACTIVATED METAKAOLIN AND ALKALINE ACTIVATED RICE HUSK ASH AS PARTIAL REPLACEMENT FOR CEMENT IN CONCRETE

ADEJOH BENJAMIN OCHOLA[1], NAZEEF MAHMOOD[2], JOSHUA ABIMIKU[3]
Department of Civil Engineering, Kaduna Polytechnic

ABSTRACT

This study Locust beans waste ash alkaline activated metakaolin and alkaline activated rice husk ash as partial replacement for cement in concrete has been investigated. The Locust beans waste ash, activated rice husk ash and metakaolin was partially replace as cement by percentage of 5%, 10%, 15% and 20% respectively. 60 number of grade 20 concrete cubes and 60 numbers of grade 25 concrete cubes were cast in laboratory and cured for 7, 14, 21, and 28 days respectively in accordance to BS1881: part 116: 1983. The study uses water/cement ratio of 0.55; with the hope that its usage would reduce accumulation of locust beans waste ash, rice husk wastes and metakaolin which is harmful to human health. The rice husk was carbonized, sieved after carbonization using sieve size 150µm and was activated in the chemical laboratory using sodium hydroxide (NaOH) as the alkaline medium. However despite the observed loss in strengths of the concrete, it can still be used for various application requiring medium and low strength in accordance to concrete grade 5, a strength which is achieved with these replacement of locust beans waste ash activated rice husk ash and activated metakaolin in concrete: such as non-load bearing concrete wall, sidewalks, road barrier, concrete block, kerbs. The amount of concrete produce worldwide for this application could ensure the viability of this study.

Keywords: *Cementious material, Compressive strength, Locust beans waste ash, Rice husk ash, Metakaolin, Pozzolana, filler,*

Introduction

Locust bean pod husks are a waste by-products of agricultural processing of the African locust bean fruit. Substantial quantities can be found across northern Nigeria during the harvest season. Across the globe, much research efforts in recent times are geared towards possible ways of recycling these wastes for reuse to keep the environment clean and safe (Adama & Jimoh, 2011). The transportation, construction, and environmental industries have the greatest potential for reuse because they use large quantities of earthen materials annually (Basha, 2003).

The African Locust bean tree (Family Legumianosae: Mimosodeae) with scientific name Parkiabiglobosa is a deciduous tree that grows up to 20m in height (Hausa: Dorowa). The tree grows in much of sub-sahara Africa and commonly found in Nigeria. It grows large fruit pods that contain both sweet yellow pulp and valuable black seeds. The seeds are used for food seasoning when fermented (Hausa: Dadawa, Igbo: Ogiri Yoruba: Iru). Various parts of the tree are also used for medicinal purposes. The brown Pod is usually peeled off to free the fruit and seeds and left as waste material. As an agricultural waste material it constitutes environmental nuisance hence its use as a building material has economic advantage. An investigation in the use of the pod extract as a binder showed that the extract improved the compressive strength of laterite blocks by 78.5% - (Aguwa & Okafor, 2012).

Rice husk ash is an agro waste material. Rice husk ash (RHA) is obtained by burning of rice husk in a controlled manner. When properly burnt, it has high silica content and can be used as an admixture in mortar and concrete. India produces about 122 million tons of paddy every year. About 20-22% rice husk is generated from paddy and 20- 25% of the total husk becomes as "RICE HUSK ASH" after burning. Each ton of paddy produces about 40 Kg of rice husk ash. Therefore it is a good potential to make the use of rice husk ash as pozzolanic material for making mortar and concrete. (Sumit Bansal, 2014).

Rice husk is an agricultural residue widely available in major rice processing countries. The husk surrounds the paddy grain. During milling process the paddy grains about 78% of weight is obtained as husk. This husk is used as fuel in the various mills to generate steam for the parboiling process. This husk contains about 75% organic volatile matter and the rest 25% of the weight of this husk is converted into ash during the firing process. This ash is known as nice husk ash. This RHA contains around 85% -90% amorphous silica. Rice husk is generated from the rice processing industries as a major agricultural by product in many parts of the world especially in developing countries. About 500 million tons of paddies are produced in the world annually after incineration only about 20% of rice husk is transformed to RHA. Still now there is no useful application of RHA and is usually dumped into water streams or as landfills causing environmental pollution of air, water and soil. RHA consists of non-crystalline silicon dioxide with high specific surface area and reactivity, thus due to growing environmental concern and the need to conserve energy and resources, utilization of industrial and biogenic waste as supplementary cementing material has become an integral part of concrete construction. Pozzolonas improve strength because they are smaller than the cement particles and can pack in between the cement particles and provide a finer pore structure. RHA has two roles in concrete manufacture, as a substitute for Portland cement, reducing the cost of concrete in the production of low cost building blocks and as an admixture in the production of high strength concrete.

Metakaolin is one of the innovative clay products developed in recent years. It is produced by controlled thermal treatment of kaolin. Metakaolin can be used as a concrete constituent, replacing part of the cement content since it has pozzolanic properties. The use of metakaolin as a partial replacement material in mortar and concrete has been studied widely in recent years. Despite of the recent studies, there are still many unknowns with the use of metakaolin. Study is needed to determine the contribution of metakaolin in the performance of hardened concrete. There are great concerns on the strength and durability of metakaolin – concrete when used as construction industries. If it is proven that the concrete is durable and strong, this lead to the use of metakaolin to replace part of the cement (Patil S.N. et.al, 2014).

The introduction of pozzolan as cement replacement materials in recent years seems to be successful. The use of pozzolan has proven to be an effective solution in enhancing the properties of concrete in terms of strength and durability. The current pozzolan in use are such as fly ash, silica fume and slag. Development and investigation of other sources of pozzolan such as kaolin will be able to provide more alternatives for the engineer to select the most suitable cement replacement material for different environments.

Unlike other pozzolan, Metakaolin is not a by-product which means its engineering values should promise some advantages compared to other cement replacement materials. In this case, studies are needed to study the performance of Metakaolin – concrete will be compared to the cost of production of Metakaolin to determine whether Metakaolin is worthy to be developed as a new cement replacement material.

Alkaline activation is a chemical process in which a powdering alumino silicate such as fly ash is mixed with an alkaline activator to produce a paste capable of setting and hardening within a reasonably short period of time.

The alkaline activation of aluminum silicates is a research line that has achieved remarkable results by comparing their properties with those of materials made of Portland cement. Alkaline-activated cements, such as those made from ceramic tile wastes (CTW), are characterized as having a high content of alkalis and a low content of calcium. For this reason, the development of the mechanical strength and durability is attributed to the reaction product or N-A-S-H gel, an alkaline aluminum silicate that presents a three-dimensional structure, quite different to C-S-H gel, calcium-silicate-hydrate, obtained from the OPC hydration. However, this gel can incorporate a small aluminum content, forming a C-(A)-S-H gel. Nowadays, the cement industry works together with the scientific community in order to minimize the negative environmental impact by using materials such as pozzolana (fly ash, silica fume, construction wastes, and ceramic tiles among others). However, they are focusing on geopolymers due to their high strength, durability, and reduction of environmental impact.

The term "geopolymer" was given to inorganic synthetic polymers of alumino silicates derived from a chemical reaction known as geopolymerization where silica and aluminum are bound tetrahedronically by exchanging oxygen atoms, forming the basic unit, a sialate monomer (O-Si-O-Al-O). It carries a negative charge excess due to the replacement of Si for Al. The charge balance in the polysiate structure is achieved by alkaline metallic cations (K or Na).

Material and Method

Locust Beans Waste Ash, Metakaolin and Rice husk Ash

Locust bean pod, which is a Waste Agricultural Biomass (WAB) obtained from the fruit of the African locust bean tree (ParkiaBiglobosa), is the material resource required for the production of locust bean pod ash (LBPA). The harvested fruits are ripped open while the yellowish pulp and seeds are removed from the pods. The empty pods are the needed raw material. The pods make up 39% of the weight of the fruits while the mealy yellowish pulp and seeds make up 61% (Adama & Jimoh, 2011).

Metakaolin is the anhydrous calcined form of the clay mineral kaolinite. Minerals that are rich in kaolinite are known as china clay or kaolin, traditionally used in manufacture of porcelain. The particle size of Metakaolin is smaller than cement particles, but not as fine as silica fume.

Rice husk ash is the ash that is obtained by the process carbonizing unit it get reduced by 25%. The rice husk for the research was obtained locally. These ashes were deliberated until fine ash is being produced. These ashes were sieved by the 600micron where further impurities are being minimized. After the process of sieving, the rice husk ash was activated so as to increase it reactivity properties before been used.

Materials

The clay Samples under investigation was subjected to activation process. The method of activation was compounded from various methods described by Bradley & Grim (1951), Grim & Kulbicki (1961) and Joshi et al (1961).

For activation, 50kg of local clay (Metakaolin) powder (12xx, BS 410) was digested with 250cm of concentrated sulphuric acid for 3hour in a mixer apparatus. After cooling, the solid washed with distilled water several times until the washings were neutral (pH 7.0).

The washing water was decanted and the solids dried at 100^{o}C for 1hour and then heated between 350 - 500^{o}C in an aching furnace for about 2hour. The solids obtained after heat activation were sieved to obtain particle size passing through mesh size 250um used for subsequent work.

The locust bean waste used in this research were sourced from Tsauni Village in Zaria L.G, Kaduna state Nigeria. The material is usually available as a waste product of agricultural processing of the locust bean fruits during the harvest season. Locust Bean Pond Ash was produced by incineration attaining 500^{o} C, after which the ash was sieved using sieve 150microns. Ordinary Portland

cement (Dangote 3X), fine aggregate (sand) and coarse aggregate (gravel) was used for casting the concrete.
Rice husk ash is the ash that is obtained by burning the rice husk until it gets reduced by 25%. The rice husk for the research was obtained locally. These husk then were deliberated until fine ash is being produced. These ashes were sieved by the 600 micron where further impurities are being minimized (Rahmat et al. 2011). Ordinary Portland cement (BUA), fine aggregate (sand) and coarse aggregate (gravel) was used for casting the concrete.

Compressive strength test
Compressive strength of concrete cube test provides an idea about all the characteristics of concrete. By this single test one judge that whether Concreting has been done properly or not.
Compressive strength of concrete depends on many factors such as water-cement ratio, cement strength, quality of concrete material, and quality control during production of concrete etc.
For cube test, casting was done using 150mm X 150mm X 150mm concrete mould. The concrete is poured in the mould and tempered 35 times in three (3) layers properly so as not to have any voids. After 24 hours these moulds are removed and test specimens are put in water for curing. The top surface of these specimen is made even and smooth. These specimens are tested by compression testing machine (digital display) after 7 days 14 days 21 days and 28 days curing. Load are applied gradually until the Specimens fails. Load at the failure divided by area of specimen gives the compressive strength of concrete.

Results and Discussion

Table 1: Compressive Strength of Control, 5%, 10%, 15% and 20% (Grade 20)

Age (Days)	Crushing strength (N/mm^2)				
	Control	**5% Repl.**	**10% Repl.**	**15% Repl.**	**20% Repl.**
7	13.58	11.44	9.96	7.94	6.76
14	16.96	14.97	12.78	10.68	8.58
21	19.24	17.99	15.49	12.59	10.99
28	23.89	20.63	17.84	14.85	11.63

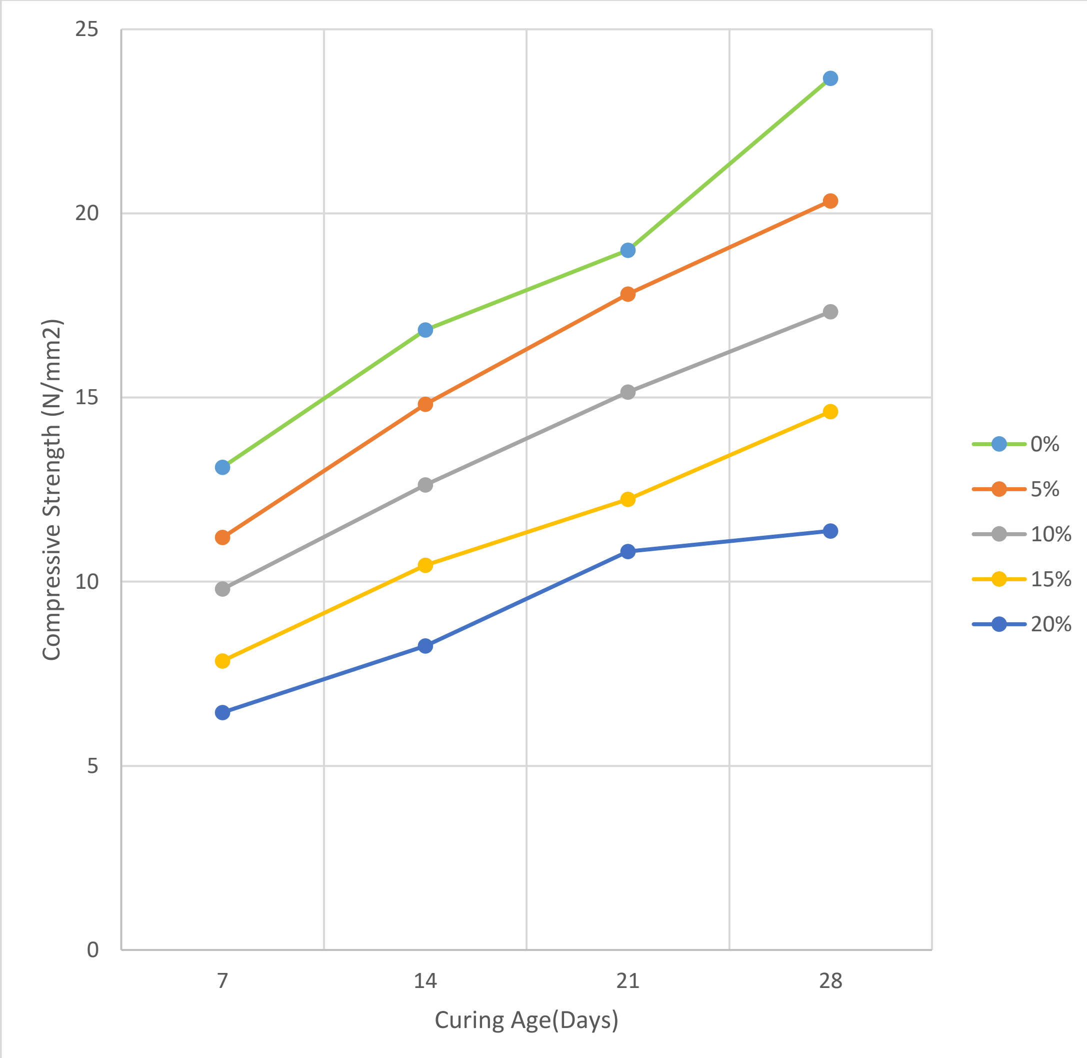

Fig. 1: A graph of compressive strength (N/mm^2) against Age (Days) for Grade 20

Table 2: Compressive Strength of Control, 5%, 10%, 15%, and 20% (Grade 25)

Age (Days)	**Crushing strength (N/mm^2)**				
	Control	5% Repl.	10% Repl.	15% Repl.	20% Repl.
7	16.95	14.60	11.78	8.93	5.98
14	18.95	16.89	14.36	11.87	8.69
21	22.86	19.52	16.86	12.96	10.73
28	27.73	22.86	18.95	15.20	12.25

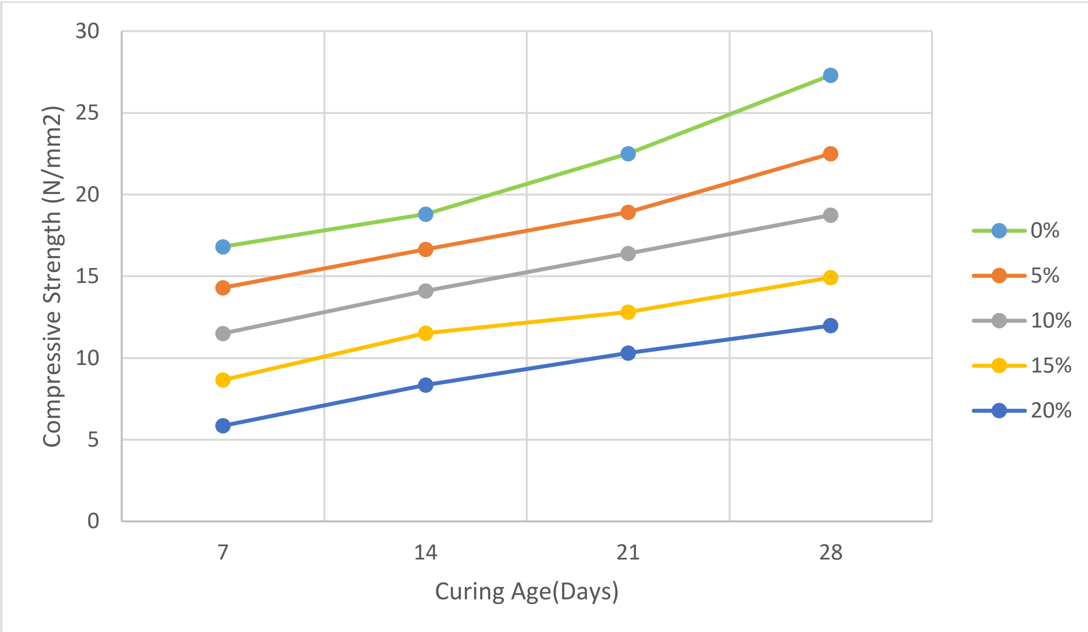

Fig. 2: A graph of compressive strength (N/mm^2) against Age (Days) for Grade 25

Discussion of Result

The result obtained from the entire test carried out on the sample of concrete is as follows:

The compressive strength grade 20 and 25 for 0%, 5%, 10%, 15% and 20% were obtained as follows: Concrete grade 20 7 days = 13.58N/mm^2, 11.44 N/mm^2, 9.96 N/mm^2 , 7.94 N/mm^2, 6.76 N/mm^2 14 days = 16.96 N/mm^2, 14.97 N/mm^2, 12.78 N/mm^2, 10.68 N/mm^2 and 8.58 N/mm^2 21 days = 19.24 N/mm^2, 17.99 N/mm^2, 15.49 N/mm^2, 12.59 N/mm^2, and 10.99 N/mm^2 28 days = 23.89 N/mm^2, 20.63 N/mm^2, 17.84 N/mm^2, 14.85 N/mm^2, and 11.63 N/mm^2. Concrete grade 25 7 days = 16.95 N/mm^2, 14.60 N/mm^2, 11.78 N/mm^2, 8.93 N/mm^2, and 5.98 N/mm^2 14 days = 18.95 N/mm^2, 16.89 N/mm^2, 14.36 N/mm^2, 11.87 N/mm^2, and 8.69 N/mm^2 21 days = 22.86 N/mm^2, 19.52 N/mm^2, 16.86 N/mm^2, 12.96 N/mm^2, and 10.73 N/mm^2 28 days = 27.73 N/mm^2, 22.86 N/mm^2, 18.95 N/mm^2, 15.20 N/mm^2, and 12.25 N/mm^2 respectively.

Therefore, the result above shows that increase in percentage of replacement decreases the strength of concrete for both grade 20 and 25 and increases in strength with increase in curing days.

The results of this trend may be due to a drop in workability with increase LBWA, Metakaolin and RHA. Test to assess the workability of fresh concrete indicates that incorporation of LBWA, Metakaolin and RHA in concrete leads to a decrease in slump value, which depends on the replacement content. This reduction in slump was due to the absorption of some quantity of mixing water by LBWA**,** metakaolin and RHA particles.
Because of the large surface area of LBWA and RHA, more water molecules were attracted towards the surface of these particles. Thus, the quantity of the free water available for the concrete mix which helps in improving the fluidity of the mixture was decreased and there was an increase in the viscosity of the concrete mix. This in turn reduces the workability of the concrete and the effect was the same for other two tests also. If density were to be considered according to BS877, the concrete mixture would have been considered a light-weight concrete.

Conclusion

From the result obtained in this study, it can be concluded that Locust beans waste ash, metakaolin and rice husk ash can be used as a potential material for replacing cement. There is an increase in strength with increase in curing age, an increase in strength with an increase in percentage replacement up to 15% of the metakaolin and rice husk ash.

Recommendations

Although, the results of this research study have shown a considerable reduction in the compressive strength of concrete with high replacement content percentage than normal concrete, it could be recommended to use in low strengths requirements structures such as non-load bearing walls, road kerb, precast units for partition walls, some cases of slabs on soil, culverts, sidewalks, concrete blocks for architectural applications and concrete blocks. Although, these research works was carried out within a specific time frame and considering the financial challenges, further study can be carried out on activated metakaolin and activated rice husk ash concrete by the additive of admixture such as silica fume of different percentage or by the use of different cement type in order to overcome the significant reduction of the concrete strength due to the replacement.

References

Adama, Y. and Jimoh, Y.A. (2011). *Production of and classification of Locust Bean Pod Ash as a Pozzolana*: Project Report. Engineering Civil Engineering Portal. Available: <http://www.engineeringcivil.com/production-and-classification-of-locust-bean-pod-ash-lbpa-as-a-pozzolan.html>.

Aguwa, J.I and Okafor, J.O. (2012). *Preliminary Investigation into the use of Locust Bean Pod Extract as Binder for production of Laterite Blocks for Buildings*. International Journal of Environmental Science and Engineering Management Research. Vol.1, No. 2, Pp. 1289-1297

Alefiya Kachwala, (2015). "Effect of Rice Husk Ash as a Partial Replacement of Ordinary Portland cementing Concrete", *International Research Journal of Engineering and Technology* (IRJET) e-ISSN: 2395 - 0056 Volume: 02 Issue: 05 | Aug-2015,

Alireza Naji Givi, Suraya Abdul Rashid, Farah Nora A. Aziz and Mohamad Amra Saleh, (2010). ''Experimental investigation of the size effects of SiO2 Nano particles on the mechanical properties of binary blended concrete. Composites: Part B 41, 2010.673-677.

Basha, E.A.; Hashim, R.; and Muntohar, A.S. (2003). *Effect of the cement - rice husk ash on the plasticity and compaction of soil*. The Electronic Journal of Geotechnical Engineering 8: Bundle A. Available: <http://www.ejge.com/2003/Ppr0304/Ppr0304.zip>.

Batis G., P. Pantazopoulou, S. Tsivilis, E. Badogiannis, (2005). "The effect of metakaolin on the corrosion behaviour of cement mortar", Cement and concrete composites, 2005, Vol 27, pp: 125-130.

Chandrakant u. mehetre, pradnya p. urade , shriram h. mahure & k. ravi4, (2014). Comparative study of properties of self-compacting concrete with metakaolin and cement kiln dust as mineral admixtures, impact: International Journal of Research in Engineering & Technology (IMPACT: IJRET), Vol. 2, Issue 4, Apr 2014, 37-52

Cook, D. J. (1986) "Rice husk ash" Concrete technology and design, cement replacement materials, R. N. Swamy, ed., Vol. 3, Surrey University Press, London, 171–196.

Deepa G. Nair, K. Sivaraman, and Job Thomas. (2013), "Mechanical Properties of Rice Husk Ash (RHA) - High strength Concrete", American Journal of Engineering Research (AJER) e-ISSN: 2320-0847 p-ISSN 2320-0936 Volume-3 2013, 14-19

Dinakar P. (2011) "High reactive metakaolin for high strength and high performance concrete", The Indian Concrete Journal, 2011, pp: 28-34.

Dr. D. V. Prasada Rao and S. Venkata Maruthi, (2016). "Effect of Nano-Silica on Concrete Containing Metakaolin". *International Journal of Civil Engineering and Technology (IJCIET)*, 7(1), 2016, pp.104–112.

Dr. Shubha Khatri, (2014). "Impact of Admixture and Rice Husk Ash in Concrete Mix Design", IOSR Journal of Mechanical and Civil Engineering *(*IOSR-JMCE) e-ISSN: 2278-1684, p-ISSN: 2320-334X, Volume 11, Issue 1 Ver. IV, Feb**.** 2014, 13-17

Erhan Guneyisi, Mehmet Gesoglu, Kasim Mermerdas, (2007). "Improving strength, drying shrinkage and pore structure of concrete using Metakaolin", Materials and structures, 2007, Vol 12, pp: 10-26.

Ernst Worrell, Lynn Price, Nathan Martin, Chris Hendriks and Leticia Ozawa Meida (2001). "Carbon Dioxide Emissions from the Global Cement Industry" Annual Review of Energy and the Environment, Vol. 26, Pg. No. 303-329.

Ganesan, K. Rajagopal and K. Thangavel (2008) "Rice husk ash blended cement: Assessment of optimal level of replacement for strength and permeability properties of concrete" Journal of Construction and Building Materials 22, Pg. no. 1675–1683.

Gemma Rodríguez de Sensale (2010) "Effect of Rice-Husk Ash on Durability of Cementitious Materials" Journal of Cement & Concrete Composites 32, Pg. no.718–725.
Gemma Rodríguez de Sensale (2010). "Effect of Rice-Husk Ash on Durability of Cementitious Materials" Journal of Cement & Concrete Composites 32, Pg. no.718–725.
Gemma Rodriguez de Sensale, (2006). "Strength Development of Concrete with Rice-Husk Ash" Journal of Cement & Concrete Composites 28, Pg. no. 158-160.
Hwang Chao-Lung, Bui Le Anh-Tuan and Chen Chun-Tsun, (2011). "Effect Of Rice Husk Ash on the Strength and Durability Characteristics of Concrete" Journal of Construction and Building Materials 25, Pg. no. 3768–3772.
Justice J. M., L. H. Kennison, B. J. Mohr, S. L. Beckwith, (2005). "Comparison of Two Metakaolin and a silica fume used as a supplementary Cementitous materials", High Performance concrete, 2005, pp: 20- 24.
Kannan, V. and Ganesan, K. (2014) "Chloride and chemical resistance of self-compacting concrete containing rice husk ash and Metakaolin" ELASIVER Construction and Building Materials 51, pp 225–234.
Khatib J.M. et.al, (2012). High Volume Metakaolin as Cement Replacement in Mortar. World Journal of Chemistry, ISSN 1817- 3128, © IDOSI Publications, DOI: 10.5829/idosi.wjc.2012.7.1.251
M.F.M. Zain, M.N. Islam, F. Mahmud and M. Jamil, (2011). "Production of Rice Husk Ash for Use in Concrete as a Supplementary Cementitious Material" Journal of Construction and Building Materials 25, Pg. no. 798-805. Concrete. "Construction and Building Materials Vol. 21, No. 8 pp. 1779-1784.
Mehta PK. (2011) Rice husk ash – a unique supplementary cementing material. In: Malhotra VM, editor. Advances in concrete technology.
Mohd Saleh, (2010). "Contribution of Rice husk ash to the properties of mortar and concrete A Review" Journal of American science: 2010.
Muhammad Soaib Ismail and A. M. Waliuddin, (1996). "Effect of rice husk ash on high strength concrete", Construction and Building Material, Vol. 10. No. 7, 1996, 521-526.
Muthadhi, A and S. Kothandaraman (2013) "Experimental Investigations of Performance Characteristics of Rice Husk Ash–Blended Concrete" ASCE Journal of Materials in Civil Engineering, Vol. 25, No. 8.
Nabi Yuzer, Zekiye Cinar, Fevziye Akoz, Hasan Biricik, Yelda Yalcin Gurkan, Nihat Kabay and Ahmet B. Kizilkanat (2013) "Influence Of Raw Rice Husk Addition On Structure And Properties Of Concrete" Journal of Construction and Building Materials 44, Pg. no. 54-62.
Patil, B.B. and Kumbhar, P.D. (2012) "Strength and Durability Properties of High Performance Concrete incorporating High Reactivity Metakaolin" IJMER Vol.2, Issue.3, ISSN: 2249-6645. Pp 1099-1104.
Rahmat Madandoust, Maleek Mohammad Ranjbar, Hameed Ahmadi Moghadam, Seyed Yasin Mousavi (2011). "Mechanical properties and durability assessment of rice husk ash concrete" Journal of Bio systems Engineering 110, Pg. no. 144-152.
Ramezanianpour A.A., P. pourbiek, M. Mahdikhani, and F. Moodi, (2009). "Mechanical properties and durability of concrete containing rice husk ash as supplementary cementing material" International Journal of Civil Engineering. Vol. 7, No. 2, June 2009, June 2010.
Rathi, V.R. and Modhera, Dr. C.D. (2014). An overview on the influence of Nano materials on properties of concrete. International Journal of Innovative Research in science, Engineering and Technology, Vol. 3, Issue 2. (2014).

Rego, J.H.S., A. A. Nepomuceno, E. P. Figueiredo, N. P. Hasparykand and L. D. Borges (2014). "Effect of Particle Size of Residual Rice-Husk Ash in Consumption of Ca $(OH)_2$" ASCE Journal of Materials in Civil Engineering.

Rossella M. Ferraro, Antonio Nanni, Rajan K. Vempati and Fabio Matta (2010) "Carbon Neutral Off-White Rice Husk Ash as a Partial White Cement Replacement" ASCE Journal of Materials in Civil Engineering, Vol. 22, No. 10.

Sabir, B.B., Wild, S. and Bai, J. (2014) "Metakaolin and calcined clays as pozzolanas for concrete : A review, Cement & concrete composites" Elsevier CCC-23(2001) pp 441-454.

Sai, A.V.S. and Rao, K.B. (2014) "A Study on Strength of Concrete with Partial Replacement of Cement with Quarry Dust and Metakaolin" ISSN: 2319-8753, Vol. 3, pp 10467-10473.

Saraswathy, V. and Song, H.-W. (2007). "Corrosion performance of rice husk ash blended M.F.M. Zain, M.N. Islam, F. Mahmud and M. Jamil (2011) "Production Of Rice Husk Ash For Use In Concrete As A Supplementary Cementitious Material" Journal of Construction and Building Materials 25, Pg. no. 798-805.

Sumit Bansal (2014). ''Effect of Rice Husk on Flexural Strength of Concrete. (Published by Research Trend, Website: www.researchtrend.net) 2319-4847.

Terrence Ramlochan, Michael Thomas, Karen A. Gruber (2000) "The effect of metakaolin on alkali-silica reaction in concrete". Cement and concrete research, 2000, Vol 30, pp: 339-344

The locust bean waste used in this research were sourced from Tsauni Village in Zaria L.G, Kaduna state Nigeria. The material is usually available as a waste product of agricultural processing of the locust bean fruits during the harvest season. Locust Bean Pond Ash was produced by incineration attaining 500^{o} C, after which the ash was sieved using sieve 150microns. Ordinary Portland cement (Dangote 3X), fine aggregate (sand) and coarse aggregate (gravel) was used for casting the concrete.

Varma, D. and Rao, G.V.R. (2014) "Influence of Metakaolin in High Strength Concrete of M70 Grade for Various Temperatures and Acidic Medium" IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) e-ISSN: 2278-1684,p-ISSN: 2320-334X, Volume 11, Issue 3 Ver. VII, pp 32-37.

Viet-Thien-An Van, Christiane Robler, Danh-Dai Bui and Horst-Michael Ludwig (2014). "Rice Husk Ash As Both Pozzolanic Admixture And Internal Curing Agent In Ultra- High Performance Concrete" Journal of Cement & Concrete Composites 53, Pg. no. 270-278.

Vivek Sood , Ashok Kumar , S.K. Agarwa (2014) Comparative Hydration Behavior of Metakaolin-Microfine System, Journal of Engineering Computers & Applied Sciences(JECAS), Volume 3, No.4, April 2014, pp:60-65

Zerbino R., G. Giaccio and G.C. Isaiah (2011). "Concrete Incorporating Rice-Husk Ash without Processing" Journal of Construction and Building Materials 25, Pg. no.371–378.