



ABSTRACT

The suitability of activated locust beans waste ash and alkaline activated rice husk ash as cementitious materials in partial replacement for cement in concrete was investigated in this study. The locust beans waste ash and activated rice husk ash were used as partial replacement of cement by percentage of 5%, 10%, 15% and 20% in concrete cube samples. 60 number of grade

ACTIVATED BLOCUST BEANS WASTE ASH AND ALKALINE ACTIVATED RICE HUSK ASH AS PARTIAL REPLACEMENT FOR CEMENT IN CONCRETE STRUCTURES

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Introduction

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 rice 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. 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

20 concrete cubes and 60 numbers of grade 25 concrete cubes were cast and cured for 7, 14, 21, and 28 days in accordance to BS1881: part 116: 1983. The water/cement ratio of 0.55 was used in this work. The locust beans was incinerated, sieved after incineration using sieve size of 150 μ m and was later mixed with the activated rice husk ash in the laboratory at equal percentage. However despite the observed loss in compressive 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 and activated rice husk ash in concrete: such as non-load bearing concrete wall, sidewalks, road barrier, concrete block, kerbs. The study is aimed towards reducing the accumulation of locust beans waste and rice husks which constitute environmental nuisance through reuse so as to avert possible public health hazards. The amount of concrete produced worldwide for the applications listed above could ensure the viability of this findings.

Keywords: Locust beans waste ash, rice husk ash, Cementious material, Environmental health hazard, Compressive strength.



as kaolin will be able to provide more alternatives for the engineer to select the most suitable cement replacement material for different environments.

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).

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).

Alkaline activation is a chemical process in which a powdering aluminosilicate 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 tetrahedrally by exchanging oxygen atoms, forming the basic unit, a silicate 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 polysilicate structure is achieved by alkaline metallic cations (K or Na).

Material and Method

Locust beans and Rice husk Ash

The ash used was obtained locally from the burning of locust bean husks. The husks were completely burnt under atmospheric condition, sealed in plastic bags and transported to the laboratory. The ash was then passed through British Standard No 200 sieve, with 0.75mm aperture, and kept to be mixed with the cement in the pre-determined percentages.

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 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° C, after which the ash was sieved using sieve 150microns. 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°C for 1hour and then heated between 350 - 500°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.

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	15.36	13.81	11.46	9.42	7.84
14	17.14	15.63	13.44	10.18	9.55
21	19.94	18.42	16.55	13.21	12.63
28	25.11	23.62	19.88	16.18	15.18

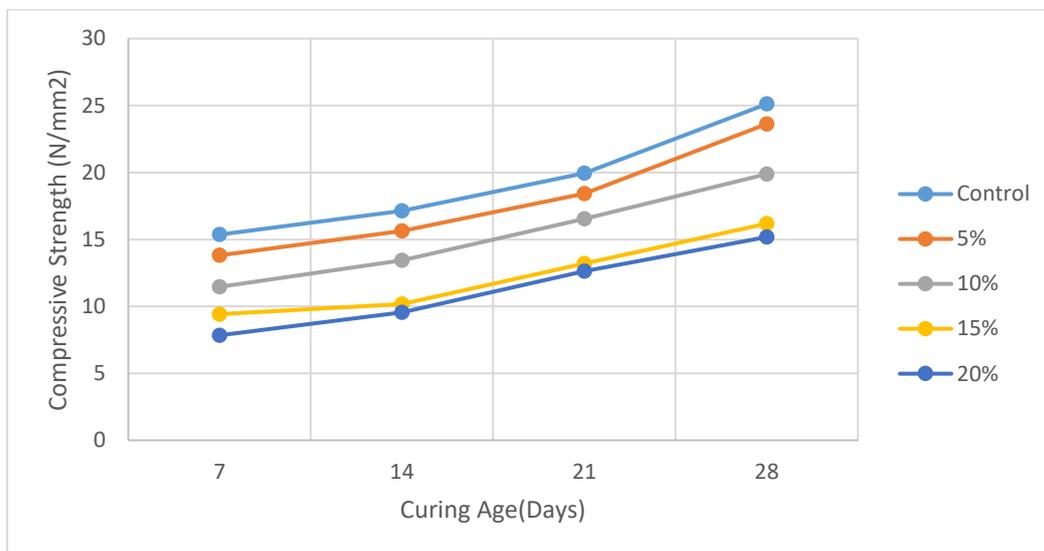


Fig. 1: A graph of compressive strength (N/mm²) against Age (Days) for Grade 20

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	19.26	18.29	16.53	14.18	13.26
14	21.44	20.37	18.14	16.46	14.28
21	23.75	22.56	20.48	17.43	15.33
28	28.46	26.16	23.44	18.26	16.92

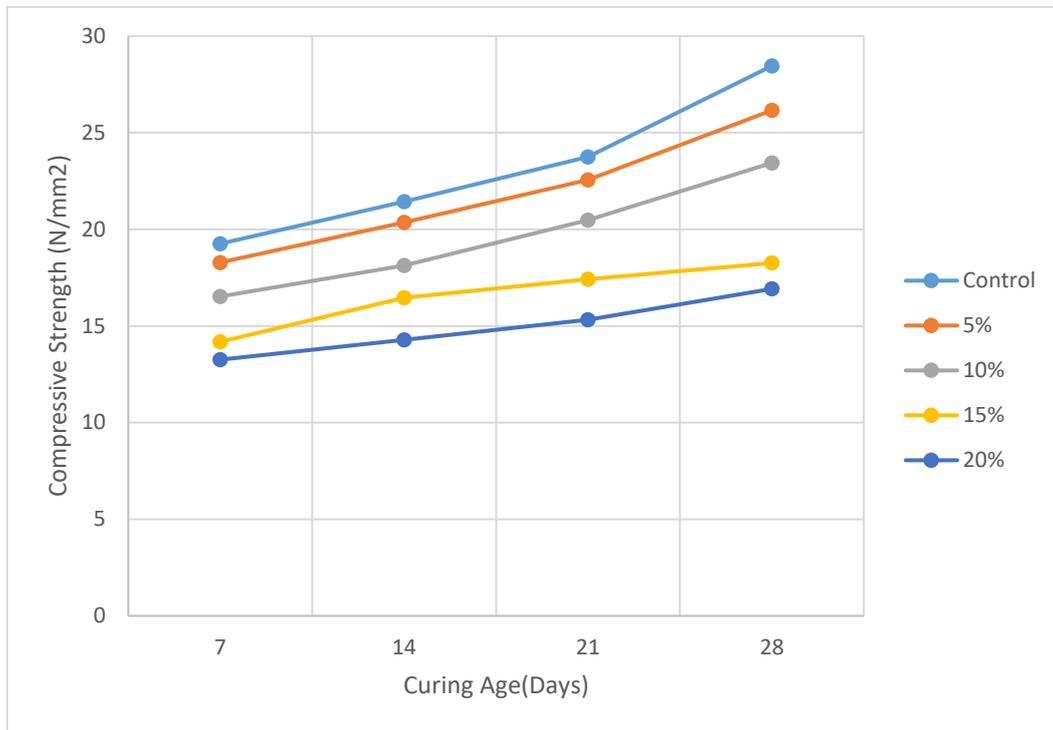


Fig. 2: A graph of compressive strength (N/mm²) against Age (Days) for Grade 25

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 = 15.36 N/mm², 13.81 N/mm², 11.46 N/mm², 9.42 N/mm², and 7.84 N/mm², 14 days = 17.14 N/mm², 15.63 N/mm², 13.44 N/mm², 10.18 N/mm², and 9.55 N/mm², 21 days = 19.94 N/mm², 18.42 N/mm², 16.55 N/mm², 13.21 N/mm², and 12.63 N/mm², 28 days = 25.11 N/mm², 23.62 N/mm², 19.88 N/mm², 16.18 N/mm², and 15.18 N/mm². Concrete grade 25 7 days = 19.26 N/mm², 18.29 N/mm², 16.53 N/mm², 14.18 N/mm², and 13.26 N/mm², 14 days = 21.44 N/mm², 20.37 N/mm², 18.14 N/mm², 16.46 N/mm², and 14.28 N/mm², 21 days = 23.75 N/mm², 22.56 N/mm², 20.48 N/mm², 17.43 N/mm², and 15.33 N/mm², 28 days = 28.46 N/mm², 26.16 N/mm², 23.44 N/mm², 18.26 N/mm², and 16.92 N/mm² 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 and RHA. Test to assess the workability of fresh concrete indicates that incorporation of LBWA 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 and RHA particles.

Because of the large surface area of 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 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 locust beans waste 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 locust



beans waste ash 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.

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