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INVESTIGATION INTO THE USE OF RICE HUSK ASH AND LOCAL DYE RESIDUE (KATSI) AS PARTIAL REPLACEMENT FOR CEMENT

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Keywords: Rice Husk Ash, Local Dye Residue, Katsi, Pozzolana, Compressive strength, Concrete, & 90 Days curing.

Abstract: This paper presents an investigation into the use of rice husk ash and local dye residue (Katsi) as a pozzolanas for partial replacement of cement in concrete production with the view of increasing its compressive strength. The effects of rice husk ash and the mixture of rice husk ash and local dye residue on the properties of fresh concrete which includes workability and density and also water absorption were determined. Compressive strength of the hardened concrete was determined from the rice husk ash and ordinary Portland cement (RHA-OPC) concrete at various percentages of 5%, 10%, 15%, & 20% and then the mixture of RHA, local dye residue and OPC concrete at various percentages of 5%(2.5% each), 10%(5%each), 15%(7.5%each) & 20%(10%each) at curing ages of 7days, 14days, 28days and 90days. The results shows the use of RHA in partial replacement of cement reduces the workability and the density when compared with concrete produced with OPC only, but the mixture of RHA and local dye residue increase the workability above that of RHA-OPC concrete but lower than OPC concrete. The concrete made with the mixture of RHA and local dye residue increases the density of the concrete above that of both RHA-OPC concrete and OPC concrete, because of the higher specific gravity of the local dye residue. Compressive strength test carried out on RHA-OPC concrete revealed a reasonable value at 5% and 10%, with a significant decrease in 15% and 20%. The concrete made with RHA and dye residue shows an increase in compressive strength above that of RHA-OPC concrete. A significant increase in compressive strength was seen at 90 days of curing age with a value 33.62N/mm^2 at 5% and a least value of 26.30N/mm^2 of RHA and dye residue concrete. Therefore, the result shows that partial replacement of cement using RHA and local dye residue was feasible at 5% to 20% replacement at curing age of 28days and 90days.

1.0 INTRODUCTION

Concrete is a predominant material used in construction, a composite material composed of coarse aggregates bounded together with fluid cement which hardens over time [1]. Cement is the essential blinding agent in concrete which is the most widely used as construction materials worldwide. Ordinary Portland cement is the most commonly type of cement in general usage [1, 2]. It is a basic ingredient of concrete, mortar and many plasters. It consist of a mixture of calcium silicate (alite, belite) aluminates and ferrites – compounds which combines calcium, silicon and aluminum and iron in forms which will reacts with water [2]. Portland cement and similar materials are made by heating limestone (a source of calcium) with clay and or a slite (a source of silicon, aluminum and iron) and grinding this product (called clinker) with a source of sulfate (most commonly gypsum).

However, cement being expensive and its production produces harmful gases [2], this necessitate the need for the replacement of cement in the production of concrete using pozzolanas such as rice husk ash, local dye residue (katsi), groundnut husk ash, wood ash, bone powder ash, bambara groundnut shell ash, acha husk ash, cassava peel ash, marble powder etc. [1, 2, 6]. The advantages by incorporating these supplementary cementing materials include energy consumption saving (in cement production), low cost, engineering properties improvement, and environmental conservation through reduction of waste deposit. Moreover, replacement of cement by these aforementioned materials can reduce of about 75 x 106 tons of CO_2 (considering a world production of about 1500 x 106 tons/year with emission of an average 1kg CO_2/kg cement)[3].

A pozzolanic material or pozzolanas has been described as a siliceous or siliceous and aluminous material [1, 2]. At ordinary temperature and with the presence of moisture it chemically reacts with calcium hydroxide (lime) to form compounds possessing cementitious properties [4]. Rice husk ash (RHA) and silica fume (SF) are considered as rich-silica materials or pozzolanic materials used to replace a portion by mass basic of Portland cement in order to modify the physical and engineering properties of cement and concrete [5].

Rice husk is a byproduct of the process of obtaining rice grain. Various useful products can be produced from rice husk such as furfural, active carbon, sodium silicate, silicon carbide, silicon nitrate etc. [6]. Its practical utilization because of economic reasons is however limited. Apart from a relatively small amount used as a low grade fuel for boilers in some rice mills, major portion of rice husk is considered a waste material and represent a disposal problems to most rice millers [7].

Amongst agricultural waste, which can be used as a source of pozzolanic materials for concrete, rice husk has a large potential due to its availability, high silica content, and low cost [8]. More than 100 countries in the world cultivate rice with an annual production of 598.5 million tons of paddy rice [9]. During the milling process of paddy rice, more than 119 million tons of rice husks are received as a byproduct [9]. On combustion, this amount of husk could yield about 23.8 million tons of ash. Burning rice husk at properly controlled temperature produces an ash consisting almost of pure silica in the amorphous form [10].

Whereas, the term Katsi is the Hausa name used for the bye product of indigo local dyeing which is predominantly carried out in Hausa land. The dyeing process is carried out in a dye pit, the inner as well as the upper edge circumference of the pit is cemented. Water is poured into the pit and barks of an Oak tree (baba in Hausa) together with ashes from burnt wood is added to it and allowed to rot in the water for some period of time. The resultant product is used for the dyeing of locally woven cotton and other materials. Then as the dyeing continues dense deposit is formed at the bottom of the pit, the deposit is scrapped and removed from the pit and left to dry out completely, it is then fired until a light grey ash is formed. This is pounded into powdered ash which is called Katsi. This katsi is highly recommended as a pozzalanas for partial replacement of cement in production of concrete [11].

Environmental problems associated with waste product disposal, resource conservation considerations and the cost of Portland cement will demand the increasing use of pozzolanas such as rice husk ash and dye residue of traditional Hausa dyeing material "Katsi" in the production of cement and precast concrete. Also cement industry is one of the most basic industries involved in the development of a country. The cement industry has been recognized to be playing a vital role in the imbalances of the environment and producing air pollution [12].

The aim of this paper is to investigate the effect of pozzalanas (Rice Husk ash and the mixture of Rice Husk ash and local dye residue (katsi)) on the compressive strength of concrete.

2.0 LITERATURE REVIEW

Concrete is a construction material composed of cement (commonly Portland cement) as well as other cementations materials such as fly ash and aggregate (generally a coarse aggregate such as gravel, or granite, plus a fine aggregate such as sand), water, and chemical admixtures [1, 2]. The word concrete comes from the Latin word "concretus" (meaning compact or condensed), the past participle of "concresco", from "com-" (together) and "cresco" (to grow) [2]. Concrete solidifies and hardens after mixing with water and placement due to a chemical process known as hydration. The water reacts with the cement, which bonds the other component together, eventually creating a stone-like material. Concrete is used more than any other man-made material in the world. Reinforced concrete and pre-stressed concrete are the most widely used modern kinds of concrete functional extensions [1, 2].

There are many types of concrete available, created by varying proportions of the main ingredients. In this way or by substitution for the cementitious and aggregates phases, the finish product can be tailored to its application with varying strength, density or chemical and thermal resistance properties [2]. Aggregates consists of large chunks of materials in a concrete mix, generally a course gravel or crushed rocks such as limestone, or granite along with finer materials such as sand.

The cement industry has been recognized to be playing a vital role in the imbalances of the environment and producing air pollution hazards. The industry releases high amount of cement dust into the atmosphere which settle on the surrounding areas forming hard crust and causes adverse impacts. The fact that air is hazardous to human health is well known. Cement industry is one of the most industries involved in air pollution [3]. The aerial discharge of cement factories consist of particulate matter, sulphur dioxide and nitrogen oxide producing continuous visible clouds which ultimately settles on vegetation, soil and affects whole biotic life around as a result the whole ecosystem around the cement factory is subjected to extraordinary stress and abuse [1, 2, 11].

2.1 Rice Husk Ash

Rice husk is the outer covering part of the rice kernel, and consists of two interlocking halves. Removed of rice husk can be done either by hand threshing or by a variety of specialized machinery. The proportion of rice husk in paddy rice depends on many factors such as variety of rice plant, location, season and cultivating methods [13]. Various amount of bran, broken rice also contributes to the difference in husk content of the paddy.

[13] Shows that, the contents of paddy rice in husk varies from about 16.3% to 26% by weight, but generally 20% is considered to be an acceptable average value. The husk on combustion yield rice husk ash (RHA), which amount to about 20% by weight, one ton of paddy will provide approximately 40kg of ash, the ash is characterized by high silica content. When rice husk is completely burnt, the silica content of the produced ash may reach over 95% by weight. Abundance, availability, siliceous nature, and low cost are the reasons that make rice husk to be used as pozzolanic materials in partial replacement of cement.

Rice husk is composed of two parts; organic matter and inorganic mineral matter. The inorganic matter consists of cellulose, lignin, pentosans and a small amount of protein and vitamins. The major inorganic mineral matter component is silica. However, the actual composition of rice husk dependent on many factors such as; type of paddy, the inclusion of bran and broken rice during milling, geographical factors and crop seasons. Others are sample preparation/method of analysis and relative humidity [7].

Burning conditions (temperature and duration) are the major factors which determine the chemical property (silica content) in RHA. [14] Had investigated on varying of burning temperature and duration on the chemical property of RHA. The RHA had been burnt from 400^0C to 700^0c for 1, 3, and 6 hours respectively. The study revealed that 95 % of silica can be produced by burning RHA at 700^0C for 6 hours. However, this silica content may not be the same even though the rice husk has been burnt in the same condition if it was taken from different location (geographical factor).

2.2 Chemical Composition of Rice Husk Ash

Chemical analysis of rice husk ash obtained after its complete burning shows that, silica is the main components, with constitution of minor amounts of alkalis and trace elements [13]. The main impurities of the ash are formed by alkalis, which contains potassium as the predominant constituent. The chemical composition of rice husk ash for burning at various furnaces is reported by [7].

[13] Revealed that, the compressive strength of Ordinary Portland Cement (OPC)-Rice Husk Ash (RHA)-Saw Dust Ash (SDA) cement composites increased with lineless after which the strength reduced, however, on the basis of compressive strength and obvious cost effectiveness, a mix proportion of 0.7:1:3.5 would be ideal for OPC-RHA-SDA binary blended cement concrete. The results seem to suggest that the variation of OPC-RHA-SDA cement concrete strength with mix proportion does not depend so much on the ratio of fine aggregates to course aggregate as on the proportion of total aggregates.

[15] Stated that, replacement of cement with rice husk ash leads to increase in compressive strength, impure the workability and achieved the target strength at 20% replacement, but also the pozzolanic activity of rice husk ash is not only effective in enhancing the concrete strength, but also in improving the impermeability characteristics of concrete, which conclude that the optimum replacement level of rice husk ash is found to be 20%.

[16] Investigated that when 21% is replaced by 16% rice husk ash and 5% marble powder, compressive strength of RHA-MP concrete is more than the normal concrete, and also when 21% cement is replaced by 10% rice husk ash and 5% marble powder, flexural strength of RHA-MP concrete is more than the normal concrete.

2.3 Dye Residue (Katsi)

The word Katsi originated from Hausa tradition as a name of the bye-product of the indigo dyeing which is predominantly practiced in Hausa land. The dyeing is carried out in a dyeing arena called ‘maruna’, in a dye pit of about 2 to 2.5 meters deep, having a diameter of about 0.5 to 0.8 meter. The upper edge circumference and the inner of the pit is cemented. The materials that constitutes the dyeing constituents includes water, backs of an oak tree and ashes, water is poured into the pit and the back of oak tree with ashes burnt from woods are added to it and allowed to decay and rot in the water for about two weeks. Then it is stirred continuously, until a muddy mixture is formed. The stirring is done consecutively for two days, then the elements responsible for the coloring is added known as 'shuni'. The resultant product is used for the dyeing of locally woven cotton, giving it its deep indigo blue color. The quantity of shuni used depends on the required color shade.

As the dyeing process continues, and the dye losses its effectiveness, a dense deposit known in Hausa as 'dagwalo' is formed at the bottom of the dye pit. The residue is left to stand in the pit for about two days after which the whole solution is removed from the pit, leaving behind a dense deposit at the base. The dense deposit is scrapped and removed from the pit and left to dry out completely. Upon drying, it is fired until a light grey ash is formed. This is pounded into powdered ash, which is called katsi (dye residue) [17].

Traditionally, katsi is used for local rendering by mixing it with the soil, mostly mixed with other materials such as 'gashin jima' and 'dafara' to make water proof cement known as 'laso'. Katsi can be found mostly in the northern region where local dyeing is predominant, particularly Kano, Zaria, Jigawa among others.

2.3.1 Chemical Composition of Dye Residue (Katsi)

The chemical composition of Katsi is shown in table below. The table shows that Katsi contains most of the chemical compounds which a typical pozzolanas contains. Katsi contains the same oxides that make up Portland cement that is CaO, SiO_2, Al_2O_3 and Fe_2O_3. Although, Katsi has a low silicon oxide, but it high calcium oxide content is very important in hydration and other cement like reactions was presented by [18]. This katsi is highly recommended as a pozzalanas for partial replacement of cement in production of concrete [18].

3.0 MATERIALS AND METHODS

3.1 Materials

The materials of interest here are the rice husk ash and local dye residue (Katsi). Their method of preparation is described here under.

3.1.1 Rice Husk Ash

Rice husk used in this project was obtained from Bauchi State, the ash was produced by burning the rice husk in brick incinerator at a temperature range of 400^0C-600^0C. The ash was sieve through a BS sieve of 150μm as seen in Figure 1.

Figure 1: Sample of Rice Husk Ash

3.1.2 Local Dye Residue (Katsi)

The katsi was obtained from kofar mata, Kano state. It was sieved through 150μm sieve size before use as seen in Figure 2.

Figure 2: Sample of Dye Residue (Katsi)

3.1.3 Cement

The cement used was Dangote 3X cement, 42.5R obtained at nearby commercial market in Bauchi town, Bauchi state.

3.1.4 Fine Aggregates

The aggregate used in this project was obtained from a commercial source in Bauchi town, Bauchi state.

3.1.5 Coarse Aggregates

The coarse aggregate used throughout the project was obtained from a commercial source in Bauchi town, Bauchi state.

3.1.6 Water

The water used was obtained from nearby well free from any physical impurities.

3.2 Apparatus/Equipment

The apparatus and equipment used in the research includes the following

i. BS standard sieves – these are used for the sieve analysis of fine aggregates and sieving of the materials.
ii. Density bottles – these are bottle used to determine the density of the materials.
iii. Concrete mixer – this is electric mixer used for the mixing of concrete.
iv. Cube Mould – these are 100mm by 100mm mould used for the casting of the concrete.
v. Mixing apparatus – these include hand trowel and any other apparatus used for mixing the concrete.
vi. Slump cone – this is the cone for determining the slump of the concrete.
vii. AIV machine – it is the machine for determination of aggregates impact value.

viii. ACV machine – it is used for determination of aggregates crushing value.
ix. Compressive strength testing machine – it is used for the crushing of concrete cubes to determine the cubes strength at different curing age.

3.3 Method

The scope of the work is to investigate the behavior of concrete produced by replacing some percentage of ordinary Portland cement (OPC) with rice husk ash. Rice Husk ash will replace Portland cement in 5% (95% cement), 10% (90% cement), 15% (85% cement) & 20% (80% cement), the mixture of rice husk ash and Katsi was used in partial replacement of ordinary Portland cement in 5% (2.5% RHA + 2.5% Katsi), 10% (5% RHA + 5% Katsi), 15% (7.5% RHA + 7.5% Katsi), 20% (10% RHA + 10% Katsi). The tests carried out include, fineness modules of fine aggregates, aggregates impact value, specific gravity (fine aggregates, coarse aggregates, rice husk ash and Katsi), and also some properties of concrete was tested based on the replaced percentage of pozzolanas. The properties are the workability of fresh concrete [19] and the density of Fresh concrete [20] and also, water absorption [21] and the compressive strength [19] of the hardened concrete was tested at 7days, 14days, 28days and 90days.

3.3.1 Preliminary Tests

The preliminary tests conducted include the determination of specific gravity of RHA, local dye residue (katsi), fine aggregates and coarse aggregates, the fineness modulus and sieve analysis of fine aggregates, and then aggregate impact value and crushing value for coarse aggregate.

3.3.2 Aggregates Crushing Value

The aggregates used for this test was sieved through 14.00mm and retained on 10.0mm sieve. The ACV mould was filled in three layers and each layer was given 17 strokes of tamping rod and the mass of the aggregates used was known. The mould was put in the ACV machine and subjected to a load of 400KN at the rate of 3.0KN/s for ten minutes. The mould was then removed and the aggregates were sieved through 3.35mm. The ratio of the mass of aggregate passing 3.35mm and that of the initial sample used multiply by 100% gives the ACV of the aggregates sample. The test was conducted in accordance with [22].

3.3.3 Aggregates Impact Value (AIV)

The test was conducted based on [23].The aggregates sieved through 14.0mm and retained on 10.0mm sieve were used. The AIV mould was cleaned and filled with aggregates in three layers, which each layer compacted with 17 strokes of tamping rod. The mass of the aggregates used was known. The mould was then fixed on the AIV machine and was given 25 blows of the AIV hammer falling freely. The aggregate was then sieved through 3.35mm sieve and the mass of the aggregate passing was measured. The ratio of the mass passing 3.35mm sieve and the initial mass of the sample used multiply by 100%, gives the AIV of the coarse aggregates.

3.3.4 Fineness Modulus of Fine Aggregates

Fineness modulus is a term indicating the coarseness or fineness of the materials. It is obtained by adding the cumulative percentage of the aggregate retained on each of the sieve and dividing them by 100. 500g of a fine aggregates sample was weighed, the sieve was arrange in descending order of the sieve sizes, the sieves used were 4.75mm, 2.36mm, 1.18mm, 600µm, 300µm, and 150µm. then the weighed sample was placed on the set up and shake with hand for about 2 -5 minutes, the shaking was done with varied motion, backward and anticlockwise. The materials retained on each sieve were weighed and the fineness modulus was calculated as in Equation (1).

$$FM = (\sum \text{cumulative percent retained})/100 \qquad \ldots(1)$$

3.3.5 Sieve Analysis of Fine Aggregates

The grading was carried out in accordance with [24]. 500 g of the sand was weighed and pass through set of sieves of 10mm, 5.0mm, 2.36mm, 1.18mm, 600m, 300m, 150m, and pan, the sieve set up was shaken manually, the particles retained on each sieve was weighed and recorded and percentage by weight of materials passing each sieve was determined.

3.3.6 Specific Gravity

The test was carried out in accordance with [25], 10g of the materials was measured, the density bottle was weighed empty as M_1, and the materials was placed in the bottle and weighed again as M_2, then water was added into the bottle to full capacity and weighed as M_3 also the mass of the bottle when filled with water only was weighed as M_4, from which the specific gravity was calculated using the Equation (2).

$$G = \frac{(M2-M1)}{(M2-M1)-(M3-M4)} \qquad \ldots(2)$$

3.4 Experimentation

In this research work, the various tests carried out include the following:

3.4.1 Concrete Mix Design

The concrete used for this project was made using cement, fine aggregates, and coarse aggregates. The concrete mix proportion was 1:2.4:2.5, and was used throughout the project. The concrete mix design was calculated using ACI method of mix design, and the percentage of cement replacement was calculated using absolute volume method. Tables 1and 2 shows the percentages of the constituent materials and mix design proportioning for RHA only. The detailed mix design can be seen in [17].

3.4.2 Casting of Cube Samples

The cement and fine aggregates were mixed using electric mixer, until the mixture was thoroughly blended and of uniform color. The coarse aggregate was added with water till the concrete becomes homogeneous. The mould of 100mm x 100mm x 100mm size was cleaned and oiled, the moulds was filled with concrete in three layers, each layer was compacted with 25 strokes of tamping rod. The top surfaces were leveled and smoothen with hand trowel. After 24hours, the cubes were then de-moulded and kept in curing tank for the required period of curing. A total of 105 cubes were cast for this project. The test procedures were in accordance with [20].

Table 1: Mix Design Proportioning (RHA and Dye Residue)

Mix No.	Cement (Kg/M^3)	RHA (Kg/M^3)	Katsi (Kg/M^3)	Fine Aggregates (Kg/M^3)	Coarse Aggregates (Kg/M^3)	Water (Kg/M^3)
M – 0	370	0	0	881.24	921	185
M – 5	356.75	9.39	9.39	901.27	938.83	187.77
M – 10	337.56	16.88	16.88	900.17	937.68	187.54
M – 15	318.42	28.10	28.10	899.06	936.53	187.31
M – 20	299.32	37.42	37.42	897.96	935.38	187.08

Table 2: Mix Design Proportioning (RHA Only)

Mix No.	Cement (Kg/M^3)	RHA (Kg/M^3)	Fine Aggregates (Kg/M^3)	Coarse Aggregates (Kg/M^3)	Water (Kg/M^3)
M – 5	356.49	18.76	900.6	938.13	187.63
M – 10	337.07	37.45	898.85	936.3	187.26
M – 15	317.72	56.07	897.10	934.48	186.9
M – 20	298.45	74.61	895.34	932.65	186.53

3.4.3 Test Carried Out on Fresh Concrete

The tests carried out on the fresh concrete are, the slump test and density test.

3.4.4 Slump Test (Workability)

The test was carried out in accordance with [21]. The cone was cleaned, and concrete was filled in three layers, each layer was compacted with 25 stroke of tamping rod, the top surface was level using hand trowel, then the cone was removed slowly and vertically upward from the cone. The difference in height between the cone and the concrete gives the slump of the concrete, which is a measure of the workability of the concrete.

3.4.5 Density (Unit Weight)

The test was carried out in accordance with [20]. A container of known mass and volume was used, then the container was filled with fresh concrete in three layers, each layer was compacted using 25 stroke of a tamping rod. The container and the concrete were weighed, and the mass of the concrete only was determined, then the ratio of the mass of the concrete to the volume of the concrete gives the density of the concrete.

3.4.6 Tests on Harden Concrete

The tests carried out on the hardened concrete cubes were, water absorption and compressive strength of the cubes.

3.4.7 Compressive Strength Test

The test specimens (cubes) were removed from water after specified curing period and allow the surface to dry, making it in saturated surface dry (SSD) condition. The base plate of the testing machine was cleaned. The specimen was placed in machine in such a manner that the load shall be applied to the opposite of the cube cast. The specimen was aligned centrally on the base plate of the machine. The machine was switch on and loaded at the rate of 3.0KN/s till the specimen failed. The maximum load was recorded.

Note: Three specimens were tested at each of the select age of curing. Average of the three specimens gives the crushing strength of the concrete. The test procedure was conducted in accordance with [19].

3.4.8 Water Absorption

The test was carried out in accordance with [19]. The concrete cubes were weighed before taking to the curing tank, after the curing period, it was then removed, before crushing the cubes, it was weighed again in SSD condition. The difference between the initial mass and the weight (SSD) is the water absorbed.

Water absorption

$$= \frac{\text{weight of water (Kg)}}{\text{weight of sample (Kg)}} \text{ X } 100\% \qquad \ldots(3)$$

4.0 RESULTS AND DISCUSSION

The results of the various tests carried out are presented and fully discussed herein.

4.1 Specific Gravity

The result of the specific gravity of the materials used are presented in Table 3, the tables shows that cement has a higher value while rice Husk ash with a value of 2.60.

Table 3: Specific Gravity

Materials	Specific Gravity
Cement	3.15
RHA	2.37
Dye residue (Katsi)	2.91
Fine Aggregates	2.60
Coarse Aggregates	2.72

4.2 Fine Aggregates

The fine aggregates used for this research work was obtained from Bauchi metropolis and sieve through sieve 4.75mm.

4.3 Sieve Analysis of fine aggregates

The result of sieve analysis performed on the fine aggregates presented in Table 4 which shows that, it was found to be in zone 2 according to [24] grading limit of fine aggregate. Figure 3 shows the graphical representation of the sieve analysis of fine aggregates result.

Table 4: Sieve Analysis of Fine Aggregates

Sieve Size	Mass Retained	% Mass Retained	% Mass Passing
10.0 mm	0.0	0	100
5.0 mm	14.0	2.8	97.2
2.36 mm	19.0	3.8	93.4
1.18 mm	58.0	11.6	81.8
600 µm	169.3	33.86	47.94
300 µm	194.4	38.88	9.06
150 µm	40.1	8.02	1.04

$\sum = 494.8$

Total sample used = 500g

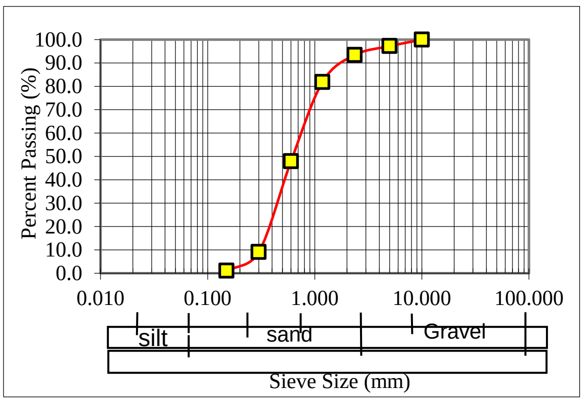

Figure 3: Graph of Sieve Analysis of Fine Aggregates

4.4 Fineness Modulus

Table 5 shows the result of the fineness modulus of fine aggregates, the fineness modulus was determined to be 2.60.

Table 5: Fineness Modulus of Fine Aggregates

Sieve Sizes	Mass Retained (g)	Cumulative Mass Retained (g)	Cumulative Percentage Retained (g)
5.00mm	10.4	10.4	2.1
2.36mm	18.9	29.3	5.9
1.18mm	50.8	80.1	16.0
600m	162.3	242.4	48.4
300m	203.5	445.9	89.1
150m	46.0	491.9	98.3

Total sample used = 500.5g

$$\text{Fineness modulus} = \frac{2.1+5.9+16.0+48.4+89.1+98.3}{100}$$

$$\text{F. m} = \frac{259.8}{100} = 2.598 \text{ and hence, F.m} \approx 2.60$$

4.5 Coarse Aggregates

The aggregates used throughout the project was sieved through 20mm and retained on 14mm having a crushing value and impact value as shown in Table 6.

Table 6: Aggregate Crushing and Impact Value

Test	Value (%)
Aggregate crushing value	36.19
Aggregate impact value	34.29

4.6 Workability (Slump Test)

Replacing some percentage of cement with RHA only reduces the workability of the concrete compared to the control result shows in Table 7, while incorporating Dye residue (Katsi) increases the workability above that of RHA only but less than the control result. The slump value reduces with increase in percentage of replacement.

Table 7: Workability (Slump Test) Results

Mix no.	Slump (mm)	
	RHA only	RHA + Dye Residue
M5	12	17
M10	7	13
M15	5	7
M20	0	2

Control Slump = 20mm

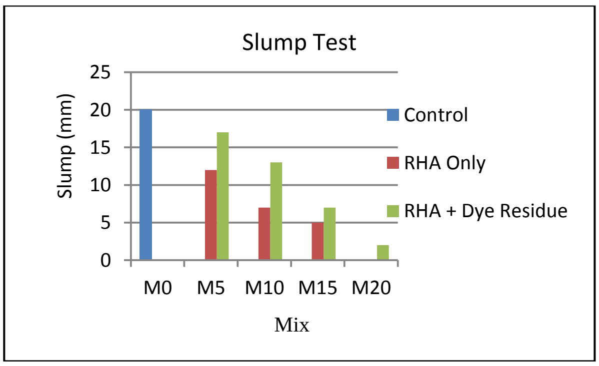

Figure 4: Chart of Slump Test

4.7 Water Absorption

Table 8 shows the summary of result obtained, water absorption increases with increase in curing days and also with increase in percentage of replacement. The RHA only have higher water absorption than the mixture of RHA and Dye residue (Katsi).

Table 8: Summary of Water Absorption

Mixture	Mix No.	Average water absorption (%) 7 days	14 days	28 days	90 days
Control	M0	1.51	1.64	2.26	
RHA Only	M5	1.10	1.22	1.33	1.47
	M10	1.13	1.39	1.53	1.82
	M15	1.35	2.05	3.08	3.72
	M20	2.09	3.13	4.52	5.92
RHA + Dye Residue	M5	1.08	1.20	1.25	1.40
	M10	1.18	1.32	1.50	1.84
	M15	1.27	1.41	1.63	2.07
	M20	1.40	2.13	3.07	4.12

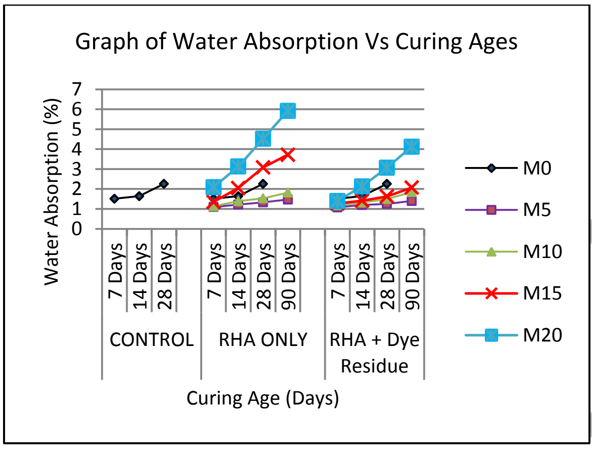

Figure 5: Graph of Water Absorption

4.8 Density of Concrete

The concrete mix was designed for a density of 2355Kg/m^3. The result shows that the density of fresh concrete of RHA decreases with increase in percentage of replacement, while the density of concrete made with the mixtures of RHA and dye residue increases the density of the fresh concrete than both the concrete made with RHA only and the control, this is because of the higher specific gravity of the dye residue (Katsi).

Table 9: Summary of Fresh Concrete Density

Sample	Mix No.	Density (KN/m^3)
Control	M0	2336.1
RHA Only	M5	2329.7
	M10	2285.2
	M15	2189.7
	M20	2164.2
RHA + Dye Residue	M5	2367.9
	M10	2348.8
	M15	2310.6
	M20	2285.2

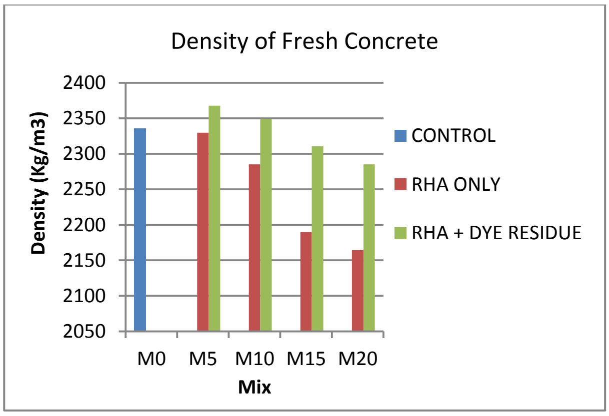

Figure 6: Chart of Fresh Concrete Density

4.9 Compressive Strength Test

The result of the test was shown in the Table 10 below, which shows that concrete made of RHA only reduces the compressive strength significantly at 15% and 20% replacement percentage. The concrete made with mixture of RHA and dye residue increase the compressive strength above that of RHA only, but a significant increased was noticed at 90 days of curing, which shows a reactive nature of a pozzolanas when they take longer period.

Table 10: Summary of Compressive Strength Test Result

Mix No.	Mixtures	Average Compressive Strength (N/mm^2) 7 days	14 days	28 days	90 days
M0	Control	25.26	26.73	27.35	----
M5	RHA only	23.22	22.97	25.59	30.21
M10		21.78	19.72	21.22	28.72
M15		15.21	15.88	20.09	25.10
M20		10.85	10.77	12.75	20.33
M5	RHA + Dye residue	22.85	24.73	26.43	33.62
M10		19.99	22.88	25.96	31.52
M15		17.12	21.83	24.23	29.36
M20		15.55	19.52	23.16	26.30

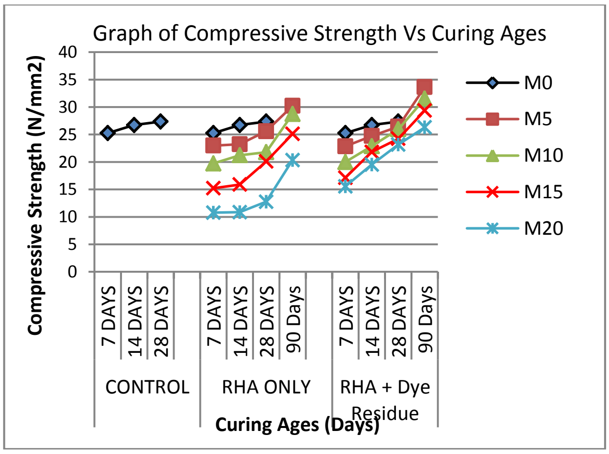

Figure 7: Graph of Compressive Strength Test Results

5.0 CONCLUSIONS

From the analysis, it can be concluded that the mixture of rice husk ash and dye residue increases the workability of the mixture of RHA alone at various percentage of replacement while the mixture of RHA and dye residue increases the density of fresh concrete above that of rice husk alone and increases with increase in percentage of replacement. Also, the water absorption capability increases with increase in percentage of replacement of rice husk ash above that of the mixture of rice husk ash and dye residue. The compressive strength showed a significant increase with the mixture of rice husk ash and dye residue and even that of rice husk ash alone, at 90 days which shows a reactive nature of the pozzolanas. Finally, it can be concluded that rice husk ash and dye residue can be used as a pozzolanas for partial replacement of cement is feasible.

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