Optimising Cement-Ash Mix in Concrete Production for Maximum Compressive Strength using Calcium Carbide Waste - Rice Husk Ash Blend

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***Abstract*:- The preliminary investigation in the use of calcium carbide waste and rice husk ash were investigated on the production of concrete (M20). The cement contents were replaced with both CCW and RHA in stepped percentages of 0, 5, 10, 15, 20 and 25% using 0.6 W/C ratio. The batching of the constitutes were done by weight and manual mixing and pouring were used. Slump test was done to establish the workability of the concrete while density and compressive test were done on the hardened concrete. The results showed that the workability and the density of the concrete peaked at 5% each of the admixtures while the compressive strength got its highest value (of the admixtures) at 5% CCW and 15% RHA. It can be concluded from the study that 15% RHA and 5% CCW could be adopted as replacement of cement in the production of concrete grade of 20.**

Keywords: Concrete, density, environment, pozzolanas, slump

1. INTRODUCTION

The construction industry relies heavily on conventional materials such as cement, sand and granite for production of concrete. Concrete is the basic civil engineering composite. The quality of concrete is determined by the quality of paste/mix. It is the world's most consumed man-made material. Its great versatility and relative economy in filling wide range of needs has made it a competitive building material (Ghoshal and Moulik, 2015). A modern life style alongside the advancement of technology has led to an increase in the amount and type of waste being generated, leading to a waste disposal crisis. Initially, the materials employed were those which could most easily be obtained from the accessible area of the surface of the earth. During the initial or conceptual design stage, consideration is given possible alternative locations and/ or layouts of the associated works and to preliminary assessment of suitable construction materials (Amologbe *et al*., 2016).

Our environment is, presently, concerned about the interims of damages caused by raw material extraction and carbon (iv) oxide emissions during cement production, as well as the high cost and price of cement in some countries, and utilization of alternative materials (otherwise termed as waste), which has contributed to the need to reduce cement consumption through the use of close substitutes. Supplementary cementitious materials (SCMs) have been proven to be effective in meeting most of the requirements of durable concrete and blended cements are now used in many parts of the world (Obilade, 2014).

According to Anifowose *et al*. (2018), rice husk is produced in rice mill in the milling process of paddy and after the burning process of rice husk in boiler the RHA is obtained. The paddy grain is surrounded by the byproduct known as husk. In the milling process of paddy approximate 78% of weight is received as rice and 22% of weight is received as husk (Gautam *et al*., 2019). The husk is use as fuel in the parboiling process for produce steam. In the firing process of rice husk, this husk has approximately 75% organic volatile substance and remaining 25% weight of husk is transformed into ash and this ash is known as rice husk ash (RHA). The RHA contains about 80-90% amorphous silica (Balogun *et al*., 2020). In every 1000 kg of paddy, approximate 22% (220 kg) of husk is produced, and around 78% (780 kg) of rice is produce. In the milling process when this husk is burnt in the boiler approximate 25% (55 kg) of rice husk ash is produced (de Sensale, 2005; Nair *et al*., 2006). Calcium carbide waste (CCW) is a chemical compound with the chemical formula of CaC2, the pure material is colourless, but most of sample have a colour ranging from black to grayish- white, depending on the grade. Its main use industrially is in the production of acetylene and calcium cyanamide (Yunusa, 2015).

This research tends to use calcium carbide waste and rice husk ash as supplementary cementing materials in concrete. The main objective of this research work is to determine the compressive strength and workability of concrete when calcium carbide is used as a partial replacement of cement

2. MATERIALS, SAMPLE PREPARATIONS AND METHODS

2.1 Materials

i) Water: Portable water which is free from suspended particles, salts and oil contamination was used throughout this study
ii) Cement: Ordinary Portland cement (OPC) – Dangote cement brands 42.5R was used
iii) Coarse Aggregate: Crushed stone (granite) of 19.0mm maximum size which conformed to IS 383-1970 was used
iv) Fine Aggregate: The fine aggregate that was used in the research was natural sand most of which passes through sieve 4.75mm and conformed to IS 383-1970.

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v) Calcium Carbide Waste: The calcium carbide will be collected from mechanic village in Ibadan Oyo state as residue of oxy-acetylene gas welding

vi) Rice Husk Ash: Rice husk ash will be obtained from nearby rice mill. It will be Calcinated at control temperature of 650^o in furnace

2.2 Sample Preparations

The quantity of each material for concrete mixes were based on the prescribed mix proportion, water/binder ratio of 0.6, aimed at obtaining 20N/mm^2 as compressive strength at 28 days curing age. The manual mixing method was adopted using shovel and tray to mix the constituent materials, which have been adequately measured according to the design mix. The mixing process continues till a homogeneous mix is achieved. To study the effect of RHA and CCW on the behavior of concrete, a total of 272 cubes with the different weight fractions of CCW and RHA were cast in 3 layers in a metallic cube mold of 150mm x 150mm x 150mm with 0%, 5%, 10%, 15%, 20% and 25% of CCW combine with 0%, 5%, 10%, 15%, 20% and 25% of RHA as partial replacement of cement in the concrete. Lubrication oil had earlier been applied at the surface of the metallic mold to minimize friction to enhance ease of removing the concrete cubes from the molds.

2.3 Methods

Particle size distribution (PSD) test

The particle size distribution was done to determine the fineness modulus of the sand in accordance to ACI Education Bulletin E1 (2007). 3kg of the dry sample was weighed and poured into arranged standard sieve set. The standard sieve set was arranged in descending series. The sample in the series was placed on the sieve shaker and sieved for 15minutes. The weight of sample retained on each sieve was determined. The percentage passing and percentage retained on each sieve was determined. The fineness modulus was calculated from the cumulative percentage passing

Slump Test

The surface of the mould was cleaned and place on a smooth, horizontal, rigid and non- absorbent surface. The concrete sample were poured in the mould on each layer of about one third of the height of the mould, and compacted with 25 blows of the rounded end tamping rod 16mm diameter. The strokes are distributed uniformly over the cross-section of the mould and the second and subsequent layers should penetrate into the underlying layer. The bottom layer is tamped throughout its depth. After tamping the top layer, the mould is filled and the concrete struck off and finished level with a trowel. The slump height and type were recorded. The procedure was repeated for all replacement level.

Slump Test on Fresh Concrete: SS EN 206-1 (2009) describe slump test as test related with the ease with which concrete flows during placement. The three kinds of slump are: natural or true slump (the concrete mould simply sinks, keeping its shape more or less), shear slump (the concrete mould falls away sideways) and collapse slump (the concrete mould collapses completely).

Density Test on Hardened Concrete: The mean densities of concrete made with different replacement level of RHA and WCC for age 7, 14, 21, 28, and 56 days curing (hydration period) was done in accordance to BS EN 12390-7: 2009.

$$Density, \rho = \frac{Weight\ of\ Cube}{Volume\ of\ Cube}\left(kg/m^3\right)$$

.............equation 3.1

Compressive Strength of Concrete: A cube of 150mm x 150mm x 150mm was used for the work. The concrete was poured in the mould and tamped properly so as not to have any voids. After 24hours the moulds were removed and test specimens were put in water for curing. The top surface of these specimens was made even and smooth. This was done by putting cement paste and spreading smoothly on whole area of specimen. These specimens were tested by compression testing machine after 7days, 28days and 56days. Load was applied gradually at the rate of 140kg/cm^2 per minute till the specimens gives the compressive strength of concrete. Plate 6 shows the process of crushing the concrete cube in the compression machine.

$$\text{Formulas for compressive strength test (N/mm}^2\text{)} = \frac{\text{Test load (N)}}{\text{Area of cube (mm}^2\text{)}}$$ ......equation 3.2

3. RESULTS

Particle size distribution (PSD): The PSD curve (as presented in Fig. 3.1) shows the cumulative percentage retain of the fine aggregate used was 280%. The result of fineness modulus was 2.8 and ACI Education Bulletin E1 (2007) reports that fineness modulus is most commonly computed for fine aggregates and generally ranges from 2.3 to 3.1.

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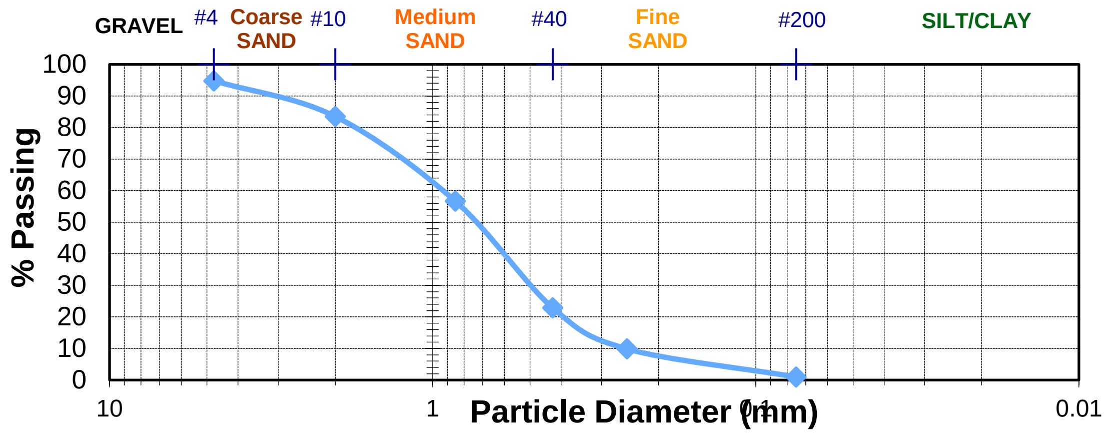

Figure 3.1: Particle size distribution of the fine aggregate

Slump Test: Fresh concretes were prepared to determine their workability using a standard cone. Table 3.1 and Fig. 3.2 show the slump tests results for the concrete with varying additions of RHA and CCW

Table 3.1: Slump Test Results

Sample (CCW, RHA)		Slump height (mm)
A	A1 (0,0)	46
	A2 (0,5)	34
	A3 (0,10)	30
	A4 (0,15)	23
	A5 (0,20)	16
	A6 (0,25)	7
B	B1 (5,0)	175
	B2 (5,5)	134
	B3 (5,10)	91
	B4 (5,15)	80
	B5 (5,20)	0
	B6 (5,25)	0
C	C1 (10,0)	60
	C2 (10,5)	51
	C3 (10,10)	44
	C4 (10,15)	12
	C5 (10,20)	0
	C6 (10,25)	0
D	D1 (15,0)	30
	D2 (15,5)	25
	D3 (15,10)	7
	D4 (15,15)	0
	D5 (15,20)	0
	D6 (15,25)	0
E	E1 (20,0)	25
	E2 (20,5)	5
	E3 (20,10)	0
	E4 (20,15)	0
	E5 (20,20)	0
	E6 (20,25)	0

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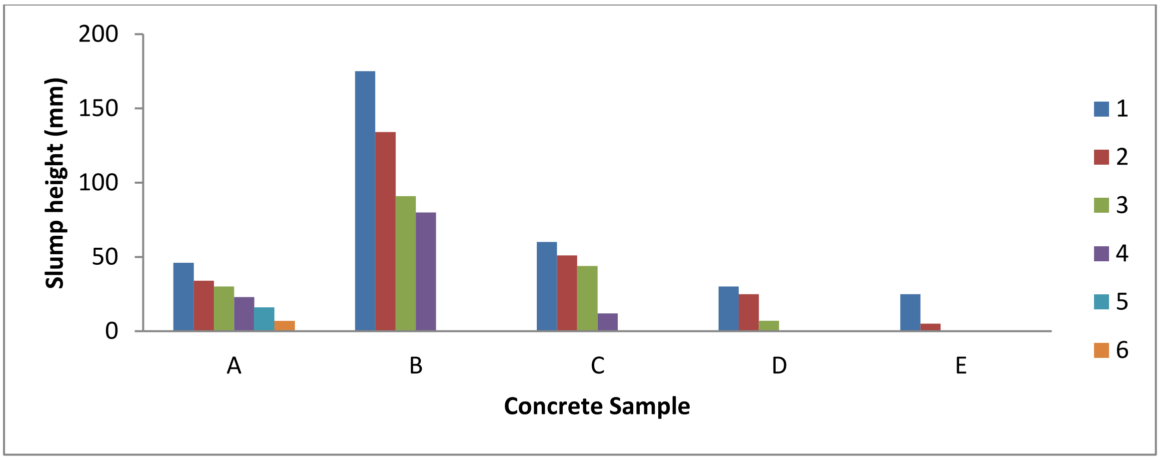

Figure 3.2: Slump test with varying RSH and CCW contents

The results indicated that the workability of the concrete decrease in increase in percentage of RHA and CCW. Concrete mix with 5% CCW produces highest workable concrete and decreases as the percentage of CCW increases.

Density

The mean densities of concrete cubes made with different % of CCW and RHA for curing age 7, 14, 28 and 56 days are given in Fig. 3.3. The density of concrete made at 56 days curing age with 0% CCW and 0% RHA has 2328 Kg/m^3 as the maximum density. The density produced from each concrete mix increases with increase in age of hydration. At each concrete mix of variation of CCW from 0%, 5%, 10%, 15% to 20% the density of the concrete decreased as the Percentage of RHA increases from 0%, 5%, 10%, 15% to 20%. The minimum density was obtained at concrete sample C4 (10%CCW, 15% RHA) at 56days age of hydration as 1977 kg/m^3. Concrete samples A1, B1, B2, D1, and D2 falls within the range of 2300 kg/m^3 – 2500 kg/m^3 specified for concrete at 28 days curing age.

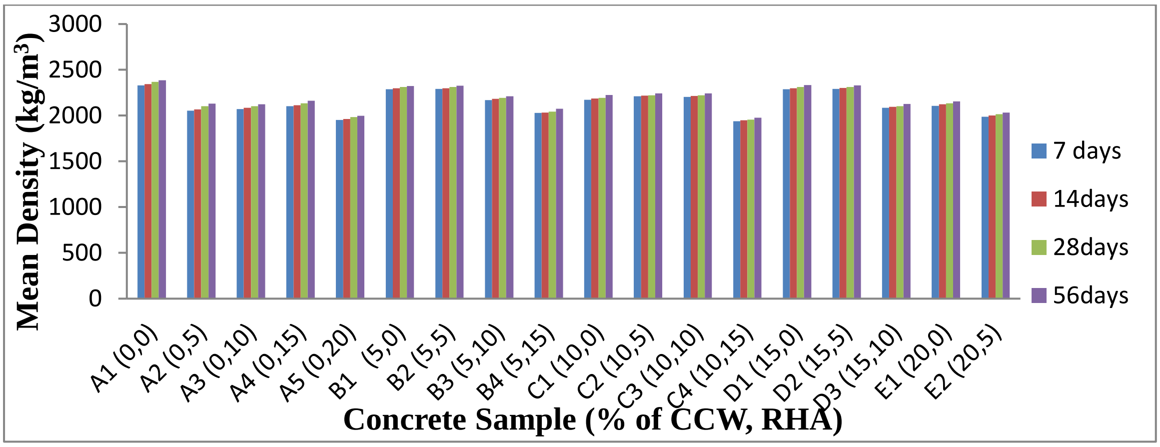

Figure 3.3: The mean density of concrete with varying RSH and CCW contents

Compressive Strength: The mean compressive Strength of the concrete mix is presented in Fig. 3.4a-d. The concrete mix of the control (0%CCW and 0%RHA) had a strength of 24.6 N/mm^2 at 56 days of hydration while that of 0%CCW and 20%RHA had the peak strength value of 28.9 N/mm^2 (see Fig. 3.4a)

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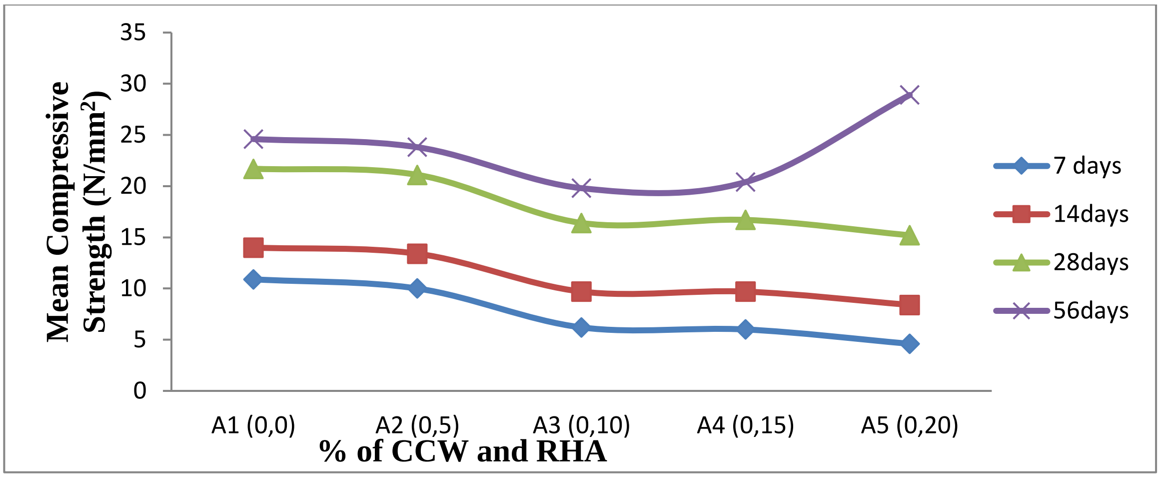

Figure 3.4a: Variation of mean compressive strength of concrete mix at 0% CCW

Combining the two admixtures, the peak compressive strength of 27.9 N/mm^2 was achieved at 5% CCW and 15% RSH at 56 days hydration (see Fig. 3.4(b-d)

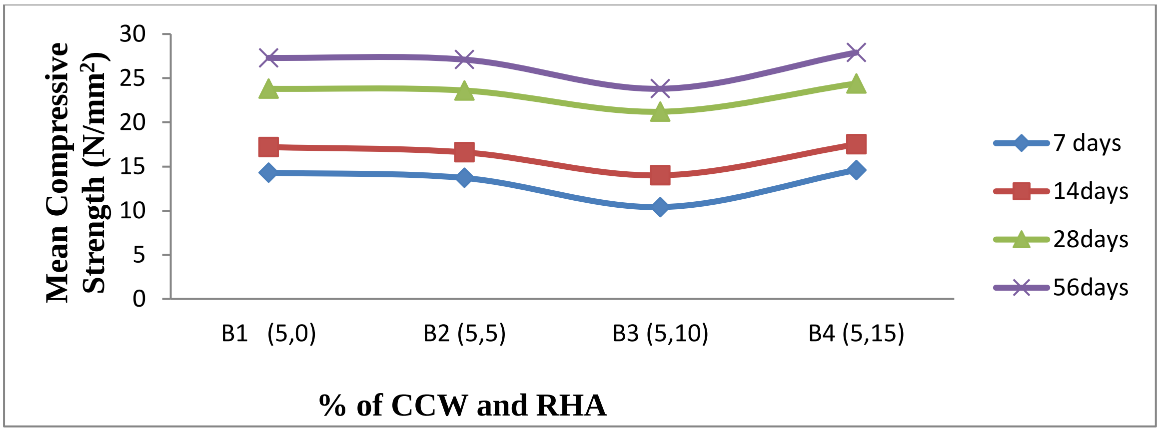

Figure 3.4b: Variation of mean compressive strength of concrete mix at 5% CCW

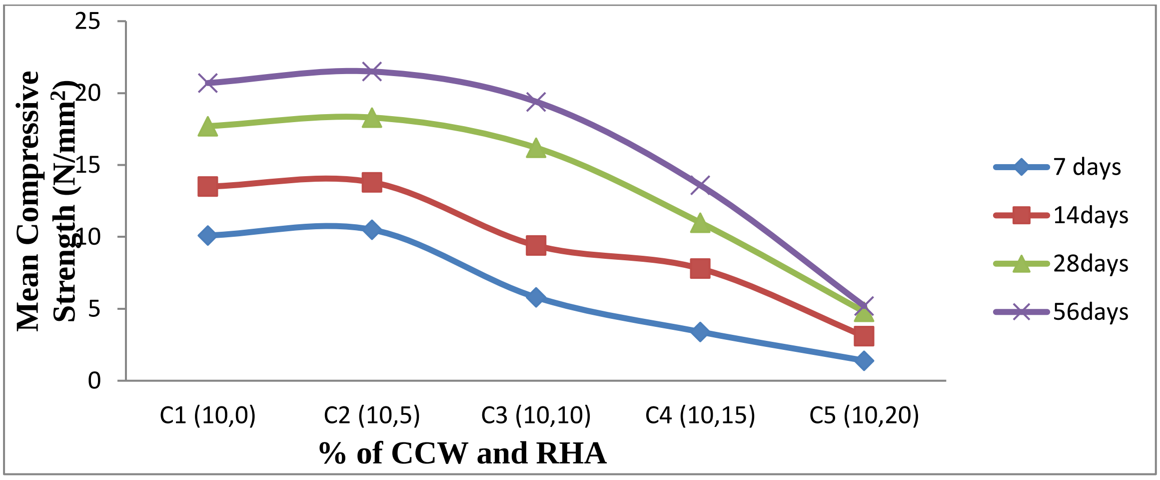

Figure 3.4c: Variation of mean compressive strength of concrete mix at 10% CCW

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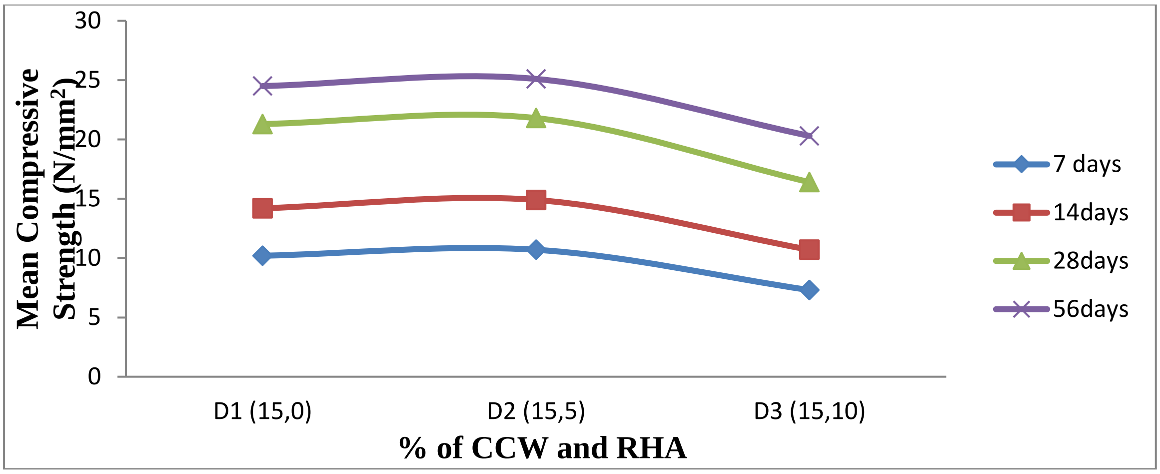

Figure 3.4d: Variation of mean compressive strength of concrete mix at 15% CCW

Generally, all concrete mix above 20% of CCW at any percentage of RHA produced weak concretes and also, all the strength of the concrete increased with hydration age

4. CONCLUSION

The use of calcium carbide waste and rice husk ash were investigated on the production of concrete (M20). The cement contents were replaced with both CCW and RHA in stepped percentages of 0, 5, 10, 15, 20 and 25% using 0.6 W/C ratio. Concrete cubes were cast and cured for 7, 21, 28 and 56 days to check the long-term effect of the admixtures in the concrete. Specific conclusions are outlined as follows:

i. The compressive strengths of the concrete increase with hydration age
ii. The slump, density and strength of the concrete increase with RHA and decrease beyond 5% addition of CCW
iii. The workability of the concrete increase with percentage increase of RHA and CCW but decrease beyond 5% CCW

It is therefore recommended that 15% RHA and 5% CCW could be adopted as replacement of cement in the production of concrete grade of 20.

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