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Durability of Sugarcane Bagasse Ash Blended Cement Concrete under Different Sulphate and chloride Concentrations

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Abstract- The study investigates the characteristics strength and durability of sugarcane Bagasse Ash (SCBA) blended cement concrete exposed to varying percentage of sulphate concentration. The principal characteristics measured was the compressive strength of ordinary Portland cement OPC/SCBA concrete at varying substitution level (0%,5%,10%,15%,20%) after curing in water and three different chemical solutions (Nacl, Na_2so_4 and $MgSO_4$) of varying concentration of 5%,10%,15%,20% each at 14, 21, 28days hydration period. The materials used in this research were S.C.B.A, sand (fine aggregate), granite (coarse aggregate), cement, clean water and chemical solution used as curing medium. The sugarcane bagasse was obtained from Yola in Adamawa State. The sugarcane bagasse was transported to federal polytechnic Ede, Osun State, where the ash was gotten by open burning of dried SCBA. The ash was sieve through 300μm was used to obtain fine particles. The chemical composition of SCBA was determined by X-ray fluorescence technique with the help of accelerator at the Centre for energy and research development OAU, Ile-Ife. The results show that the OPC/SCBA concrete performed best in these chemical solutions, at 5% and 10% SCBA replacement which exhibited a convincing compressive strength competing with that obtained with the use of Ordinary Portland cement. The study concluded that OPC/SCBA concrete has shown resistance to these media(Nacl, Na_2So_4 and $MgSo_4$) at these curing stages, could be used in building and civil engineering works in sulphate environment and where early strength is a major requirement, thereby reducing the cost of concrete production.

Keywords: Blended cement concrete, Compressive strength, Sugarcane bagasse Ash, Sulphate concentration.

1.0 Introduction

[1] Admitted that the demand for building materials especially cement has continuously risen because of increase in the need for more buildings in both rural and urban areas. [2] Emphasized that cement materials play a vital role in the production of concrete. With the ever-increasing demand for cement and in the backdrop of waste management, researchers all over the world are in the quest for developing alternative binders that are friendly to the environment and contribute towards sustainable management. The incorporation of agricultural by-product pozzolanas has been studied with positive results in the manufacture and application of blended cement.[3-4] found a good prospect in partially replacing cement with periwinkle shell ash in river stone aggregate concrete.[5]Successfully applied groundnut shell ash as a partial replacement for cement in concrete production in a sulphate environment[6] studied the behaviour of bamboo leaf in a sulphate environment. SCBA is recently accepted as a Pozzolanic material, and its uses are limited. Most of the sugarcane bagasse is dispersed in the land-fill, the waste like other biomass is well suitable as fuel for energy generation and the ash produced are used in construction. However, only a few studies have been reported on the use of sugarcane bagasse ash as Pozzolanic material.[7] Examined the possibility of using sugarcane bagasse ash as replacement of fine aggregate in concrete, with the positive result at a maximum of 10% replacement. [8] Studied the structural and durability characteristic of SCBA. The result showed that the strength of concrete increased as the percentage of bagasse ash replacement increased. The above researchers only concentrated their efforts on the suitability of SCBA/ OPC blended concentrate in the natural environment.

With the above reasons, this paper investigates the short-term characteristic strength of sugarcane Baggase ash blended cement concrete in sulphate concentration. The principal characteristic measured was the compressive strength of various percentage of chemical concentration of $Nacl_2$, $NaSO_4$ and $MgSO_4$ as curing medium. The choice of the percentage substitutions (SCBA) used and hydration period was based on a similar research carried out by [5]. On characteristics Strength and Durability of Groundnut Shell Ash (GSA) Blended Cement Concrete in Sulphate Environments,[9] Factors Influencing the Sulphate Resistance of Cement Concrete and Mortar and [6]on Bamboo leaf Ash which, they reported that 10% substitution of pozzolanas with cement in blended concrete was acceptable compared with required standards.

2.0 Materials and Method

The materials used in this research were S.C.B.A, sand (fine aggregate), granite (coarse aggregate), cement, clean water and chemical solution used as curing medium. The sugarcane bagasse was obtained from Yola in Adamawa State. The sugarcane bagasse was transported to federal polytechnic Ede, Osun State, where the ash was gotten by open burning of dried SCBA. The ash was sieve through300µm was used to obtain fine particles. The chemical composition of SCBA was determined by X-ray fluorescence technique with the help of accelerator at the Centre for energy and research development OAU, Ile-Ife. The results of physical analysis and chemical properties of SCBA are presented in table 3.1.1(a) and 3.1.1(b)

The Coarse aggregate used was granite stone. It was of high quality and free of deleterious organic matter and the 20mm maximum sieve size was used. Also, the silicon fine aggregate used was obtained from a river with 4.75mm maximum sieve size. Before the sand was used, it was dried to remove the moisture content so that it will not increase the water content in the concrete mix. Dangote brand of Ordinary Portland Cement was used as the main binder. It conforms to type 1 cement as specified by [10].The water satisfies [11] requirements.

2.1 Sieve Analysis

It was used to determine the fineness modulus an index. The test was carried out for SCBA and sand based on standard procedure [12] and [13]. Percentage of soil and Ash retained on each sieve was calculated according to the mass retained on each sieve to the total mass of soil sample taken % Retained on any sieve.

$$= \frac{\text{Weight of soil/ ash retain}}{\text{Total soil weight/ ash weight}} \times 100$$

Percentage passing = 100- Cumulative percentage of soil or Ash retained. The result enables to determine whether the aggregate met the grading requirements of [14].

2.2 Mixes

A concrete mix ratio of one-part cement with two parts fine aggregate and four-part coarse aggregate ratio was adopted for the production of concrete cubes. Cement content was replaced at 5%, 10%, 15% and 20% with SCBA. The adopted substitution levels were based on previous similar works conducted by [3, 5, 6, 9], which recommends between 10%- 40% as the most suitable replacement level for Blended concrete. The moulds used were cleaned with black engine oil to prevent the development of a bond between the mould and the concrete. The freshly mixed concrete was scooped into the mould. Each mould was filled in three layers with the concrete; each layer was rammed 25 times with a tamping rod. 150mm x 150mm x 150mm cubes were produced for the tests. A total of 80 cubes were cast. Concrete cubes were stripped from the mould carefully after 24 hours of the concrete setting under air. All the cubes were cured in water and sulphate media for a maximum hydration period of 28days respectively. Average of three cubes was crushed for each test. The results of the analysis are showed in Figures. 3.1.2

2.3 Setting Time

Values obtained as the initial setting time for OPC and OPC/SCBA pastes were 2 hours 35 minutes and 3 hours 45 minutes respectively. Final setting time values were obtained for OPC and OPC/GSA pastes as 3 hours 20minutes and 4 hours 12 minutes. The setting time values obtained were within the recommended range of 30 minutes to 10 hours stipulated by [15].

2.4 Concrete Curing

After 24hours concrete cubes were stripped from the mould and immersed in curing tank. The curing procedure was carried out in basically two media which are controlled medium (water) and salt solutions. The procedures followed were in accordance with the requirements of [16] and the curing was conducted based on specific curing age at each level or age effect of each salt were noted and carefully observed. The curing lasted for 28days.

2.5 Compressive Strength Test

Before crushing the cubes they were brought out of the curing medium and kept for 30minutes for the water to dry off. They were then taken to the crushing machine in accordance with [4], the cubes were crushed and the result of the load applied by the crushing machine and the reading were taken.

$$\text{Compressive strength} = \frac{\text{Applied load(N)}}{\text{Cross-sectional area of the specimen}}$$

3.0 Discussion of Result and Analysis

3.1 Chemical and Physical Properties of sugarcane Baggase Ash

Table 1: Physical properties of SCBA

Specific gravity of SCBA ash	1.44
Moisture content	0.46%

Source: Field Survey, 2017

The Specific gravity of SCBA is being 1.44 as stated in Table 1. This value is less than 2.25 and1.54 reported by [6] and [5] for BLA and GSA Fuel Ash respectively. These values are less than the average value of 3.15 for Portland cement. This means that a considerable greater volume of cementious materials (SCBA) will result from mass replacement. The moisture content is in agreement with the value reported by [11] which was 0.43%.

Table 2: Chemical Analysis of Sugarcane bagasse Ash and OPC

Constituent	% Composition (SCBA)	% Composition (OPC)
Ferrous oxide (Fe_2O_3)	1.01	4.60
Silica (SiO_2)	10.21	22.00
Calcium Oxide (CaO)	8.62	62.00
Aluminum Oxide (Al_2O_3)	6.03	5.03
Magnesium Oxide (MgO)	9.14	2.06
Sodium Oxide (Na_2O)	9.02	0.19
Potassium Oxide (K_2O)	19.83	0.40
Sulphite (SO_3-)	4.20	1.43
I.L	3.60	2.82
Other Oxides	<0.1	<0.1

Source: Laboratory analysis, 2017

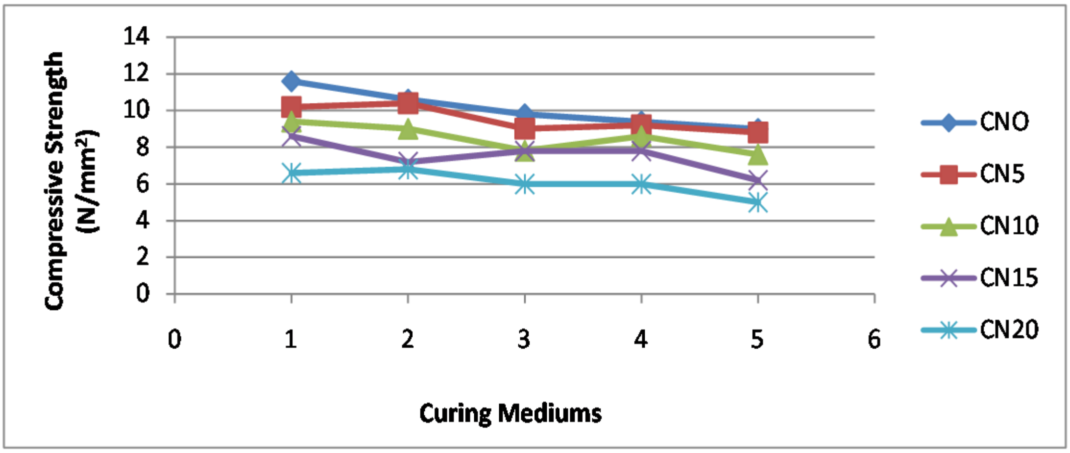

Figure 1: Compressive Strength of OPC and OPC/SCBA cured in water and 5%,10%,15%,20% solution of $Nacl_2$ at 14days of hydration.

In Figure 1 above, the OPC concrete was affected by the action of NaCl, but OPC/SCBA performed optimally at 5%, 15% and20% with slight decrease in strength from 11.80 to 10.00N/mm^2 at 5% and10% salt solution, this is maybe as a result of early age of concrete at 14 days of hydration.

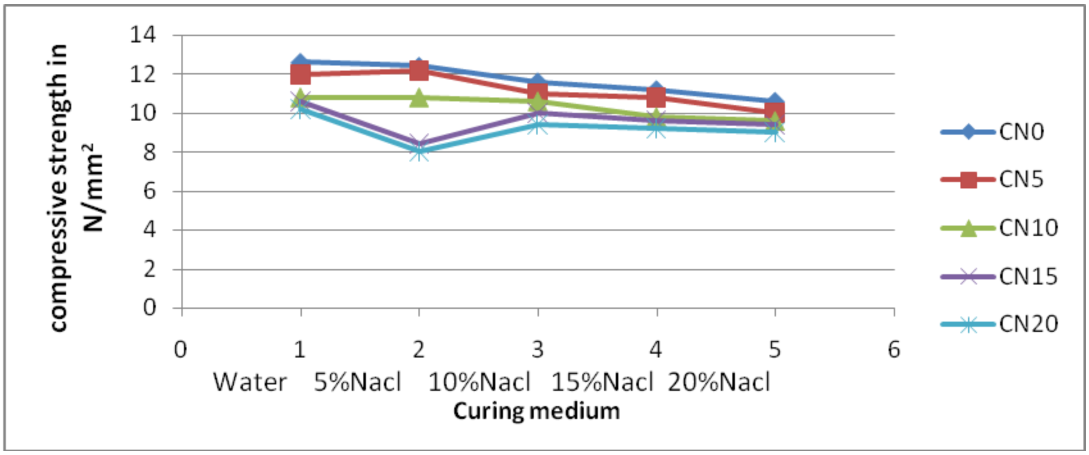

Figure 2: Compressive Strength of OPC and OPC/SCBA cured in water and 5%,10%,15%,20% solution of NaCl at 21days of hydration.

In Figure 2 above, the result at 21days of hydration shows that OPC and OPC/SCBA at 0% to 10% does not show any reasonable response both in $Nacl_2$ and water medium, but shows a slight increase in strength in the solution of 10% $NaCl_2$.

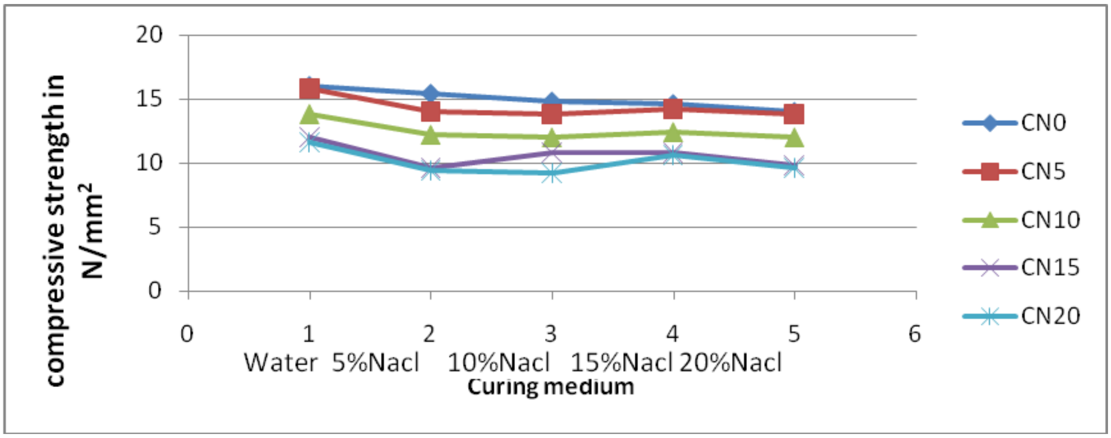

Figure 3: Compressive strength of OPC and OPC/SCBA cured in water and 0%,5%,10%,15%,20% solution of $Nacl_2$ at 28days of hydration.

In Figure 3 above, it was observed that there is a consistent improvement in the strength of concrete with both OPC and OPC/SCBA at this curing age. This result shows that SCBA/OPC concrete can be used in peninsula area where soil contained a certain percentage of salt.

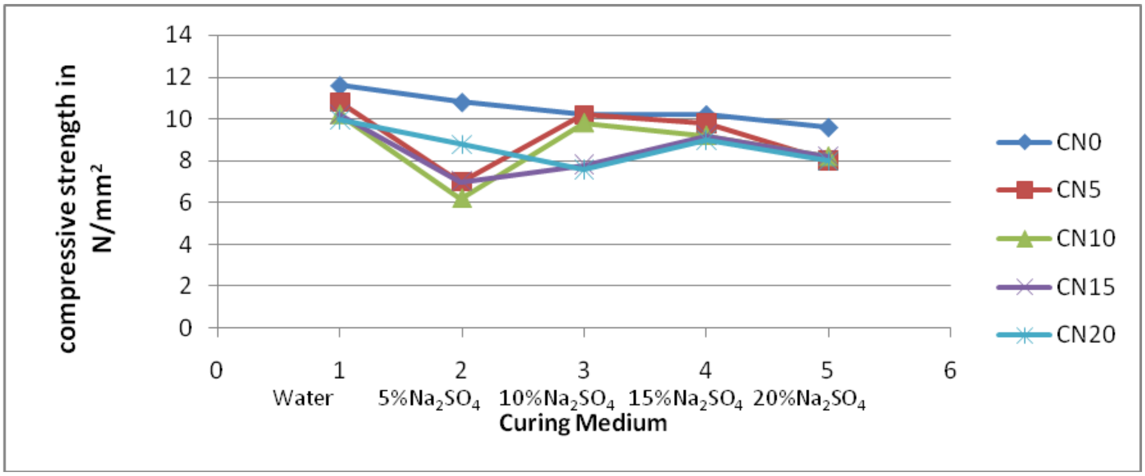

Figure 4: Compressive strength of OPC and OPC/SCBA cured in water and 0%,5%,10%,15%,20% and solution of Na_2S0_4 at 14days of hydration

In Figure 4 above, the result at 14dayshydrationperiod indicates that OPC concrete is not affected by the action of the sulphate. The OPC/SCBA shows no loss of strength until it reaches 15% in Na_2SO_4 solution, this indicates that the SCBA is a pozzolan as the result is similar to those reported by [3, 4, 5, 6, 9] in their various and similar researches.

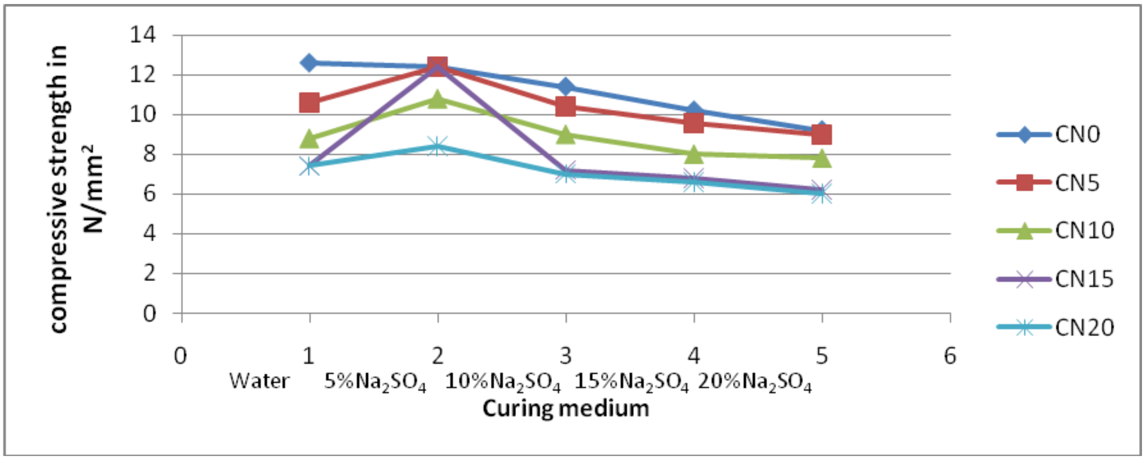

Figure 5: Compressive strength of OPC and OPC/SCBA cured in water and 0%,5%,10%,15%,20% Solution of Na_2SO_4 at 21 days of hydration.

In Figure 5 above, the result indicates slight lost in the strength of OPC concrete in Na_2SO_4medium but stable performance for OPC/SCBA concrete, especially at 5% substitution level at all level of concentrations.

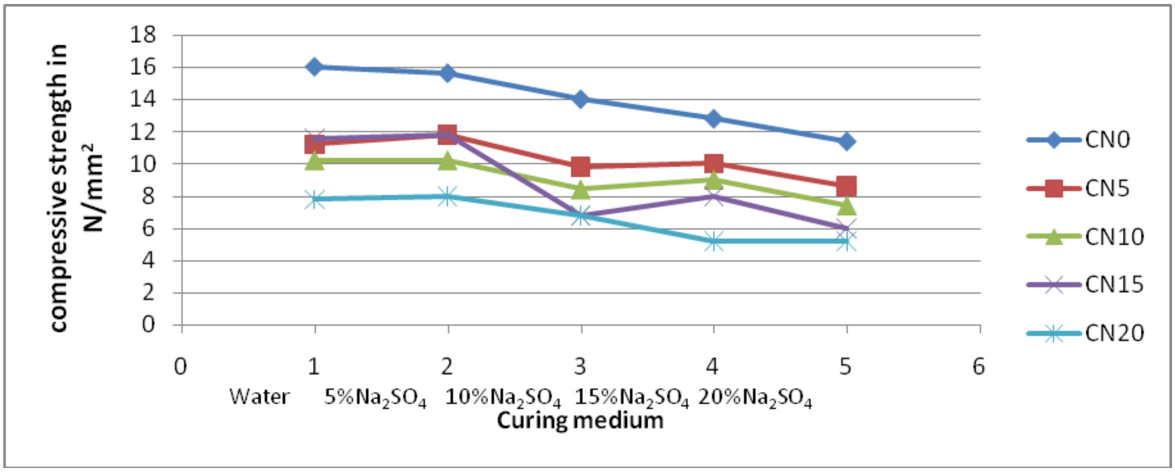

Figure 6: Compressive strength of OPC and OPC/SCBC cured in water and solution Na_2SO_4 in 28 days of hydration.

In Figure 6 above, the result indicates that at 28days of hydration, OPC concrete shows slight loss of strength while OPC/SCBA at 10% replacement tends to improve in strength at 15% Na_2SO_4 solution.

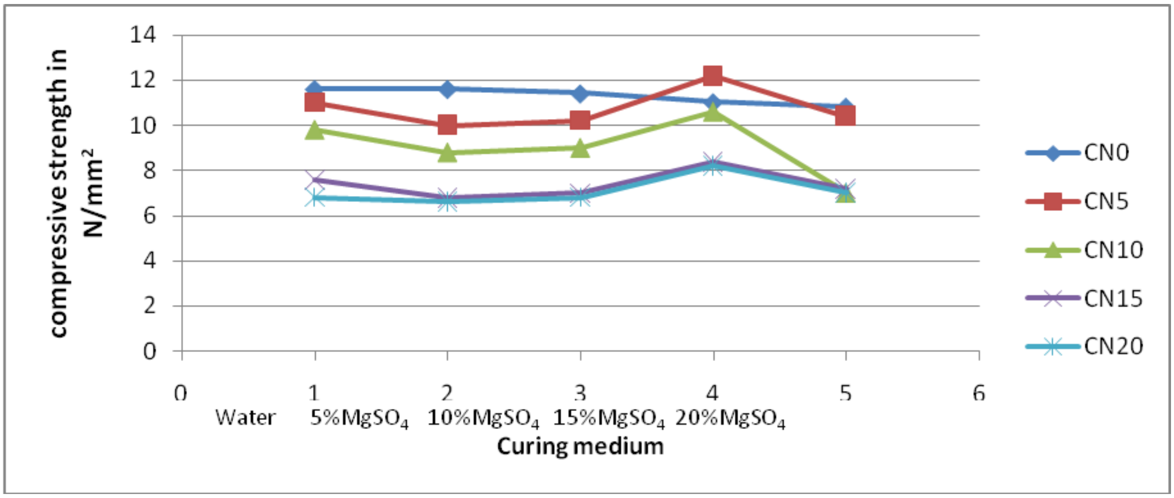

Figure 7: Compressive strength of OPC and OPC/SCBA cured in water and 0%,5%,10%,15%,20% Solution of $MgSO_4$ at 14 days of hydration

In the Figure7 above, the results show that OPC/SCBA concrete performed better in $MgSo_4$ at 5%, 10%, 15% and 20% replacement, while the OPC experienced loss of strength at 14days of hydration.

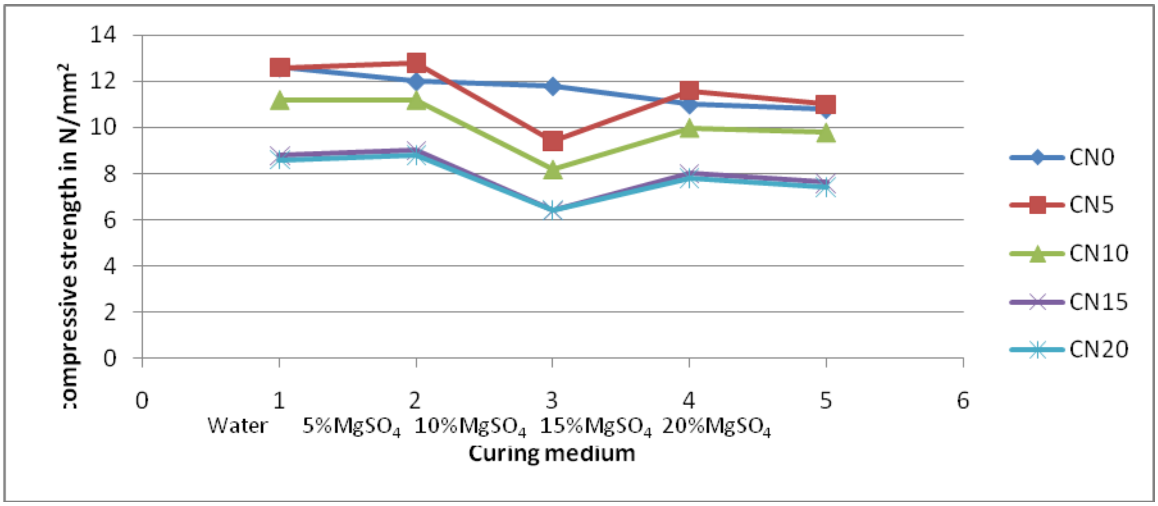

Figure 8: Compressive strength of OPC and OPC/SCBA cured in water and 0%,5%,10%,15%,20% Solution of $MgSO_4$ at 21 days of hydration.

The Figure 8 above revealed that the OPC shows slight loss of strength in the solution of $MgSO_4$ concentration while OPC/SCBA had an inconsistent value at 10% substitutions level. This inconsistent indicate the limitation of the use of OPC/SCBA blended concrete in a sulphate environment beyond 5% substitution level.

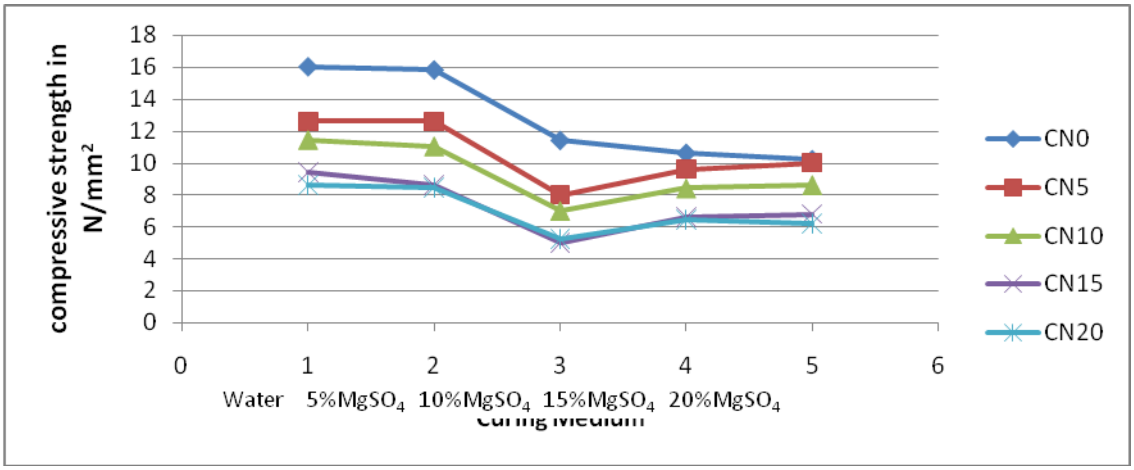

Figure 9: Compressive strength of OPC and OPC/SCBA cured in water and 0%,5%,10%,15%,20% Solution of $MgSO_4$ at 28 days of hydration

In the Figure 3.9 above, the result shows slight loss of strength in OPC concrete while OPC/SCB shows loss of strength completely in the solution of $MgSO_4$ except that of 5% at 28days of hydration. It can be concluded that the use of SCBA/OPC blended concrete in the $MgSO_4$environment may not be viable beyond 5% substitution level.

4.0 Conclusion

Based on the experimental result, the following conclusions were drawn

1. SCBA is a good Pozzolanic material which reacts with calcium hydroxide forming calcium silicate hydrate. The Pozzolanic activity of SCBA increases in the normal environment with an increase of time.
2. The specific gravity of the SCBA gotten was less than that of the OPC it replaced, this means that a considerable greater volume of cementitious materials will result from mass replacement.
3. The compressive strength value of the SCBA/OPC blended concrete at 10% replacement level performed better and would be acceptable and considered as a good development for construction of masonry walls and mass foundations in low-cost housing in Nigeria.

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