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Effects Of Chemical Attack On Corn Cob Ash Concrete

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Abstract: *In this research work, resistance of CCA concrete to chemical attack was tested. Cubes of 150 mm x 150 mm x 150 mm dimension with varying percentages by weight of CCA to cement combination in the order of 0 %, 10 % and 20 % were cast using a 1: 2: 4 mix ratio and a water-cement ratio of 0.5. The durability performance of corn cob ash was investigated in this study. Durability tests were carried out on the CCA concrete to study the behaviour of the samples after immersing them in 5 % acid (H_2SO_4), 5 % alkaline (NaOH) and 5 % sulphate (Na_2SO_4) solutions for 90 days. The effects of these aggressive environments on the concrete cube specimens were investigated and analysed. Visual inspection, weight loss, density and compressive strength tests on the CCA concrete were carried out. From the study, it was observed that as the proportion of CCA in concrete increased, the rate of weight loss, surface deterioration and strength loss in acid, alkali and sulphate solutions increased.*

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I. Introduction

Concrete performs well when exposed to various atmospheric conditions, water, soil, and many other chemical exposures. However, some chemical environments can deteriorate even high - quality concrete. When a concrete structure is prone to chemical actions, its durability gets affected. The chemicals may cause cracking of concrete, volume change and deterioration of structure. The life of structure reduces and it can lead to failure of structures [52].Concrete is rarely, if ever, attacked by solid, dry chemicals. To produce significant attack on concrete, aggressive chemicals must be in solution and above some minimum concentration.

II. Material And Methods

2.1 Cement

In this work, Dangote brand of ordinary portland cement (OPC) from a single lot was used throughout the research. Cement was sourced from Abuja and carefully stored to avert deterioration in its properties. It is a type 1 cement in accordance with [54].

2.2 Fine aggregate:

For the present investigation, stone dust gotten from a quarry in Abuja was used as fine aggregate. It was clean, free of dirt, dust, clay and organic matter.

2.3 Coarse aggregate:

Coarse aggregate used in this study was made up of granite obtained from a quarry in Abuja. It was clean and free of organic matter, chemical matter, flaky and elongated materials.

2.4 Water:

In this present work, potable water free of visible impurities was used for mixing and curing of concrete. It was clean, colourless fresh water from the tap of the Faculty of Engineering, University of Abuja.

2.5 Corn cob ash

For this study, corn cob used was obtained from Ejiba, Kogi State in dry form. It was finely grinded to aid combustion and burnt into ash with the aid of a furnace at a temperature of 650 ^{o}C. A 75 µm sieve was used to sieve the CCA and the residue was thrown away while those passing through were used for this experiment.

Table 1: Shows the oxide composition of the CCA as determined through X-ray fluorescence at the Nigerian Geological Survey Agency, National Geosciences Research Laboratory (NGRL), Kaduna State.

Table 1: Oxide composition of CCA

Constituents	Percentage Composition of CCA
Aluminum Oxide (Al_2O_3)	17.9
Silicon dioxide (SiO_2)	62.2
Potassium Oxide (K_2O_3)	2.61
Calcium Oxide (CaO)	2.96
Manganese Oxide (Mn_2O_3)	1.69
Iron Oxide (Fe_2O_3)	9.13
Copper Oxide (CuO)	0.22
Titanium Oxide (TiO_2)	0.49
Potassium Oxide (K_2O_3)	2.13

2.6 Chemical solutions

Table 2: Shows the properties of the acid, alkaline and sulphate used in this study.

Table 2: Properties of sulphuric acid, sodium hydroxide and sodium sulphate

Molecular formula	H_2SO_4,	NaOH	Na_2SO_4,
Molar mass	98.08 g /mol	40.01 g/mol	142.04 g/mol
Appearance	Colourless, odourless liquid	colourless crystalline solid	white crystalline solid hygroscopic
Density	1.84 g/cm^3	2.120 at 20/4 ^{o}C (water = 1)	2.664 g/cm3 (anhydrous)
liquid Melting point	10 °C, (50 °F)	318 °C (604 °F)	884 °C (anhydrous)
Boiling point	337 °C, (639 °F)	1,388 °C (2,530 °F)	1429 °C (anhydrous),
Solubility	Miscible in water	highly soluble in water	4.76 g/100 ml (0 °C). 42.7 g/100 ml (100°C)
Acidity (pK_a)	4.76 at 25 °C	78 mPa·s	
Viscosity	26.7 Pa·s (20 °C)		

2.7 Durability tests

The specimens were initially cured in water for 28 days after which theconcrete cubes were removed from water and allowed to adequately dry before putting them into 5 % solutions of sulphuric acid, sodium hydroxide and sodium sulphate. Visual inspection was periodically done on concrete cube specimens that have been put into the chemical solutions. After immersing the concrete cubes in the chemical solutions for 90 days, the weight losses, density and compressive strengths of the specimens were tested and recorded. The percentage replacements by weight of OPC by CCA were 0 %, 10 % and 20 %. After the curing period, comparison was made to ascertain the residual strength of each set of the soaked cubes. Comparison was made with the designed strength and the control.

2.8 Regression models for compressive strength

The coefficients for the regression equations were calculated using Microsoft Excel Office Package. Function Y is the mathematical model for predicting compressive strength of CCA concrete in the different media (acid, alkali, sulphate and water) while factor X is the percentage CCA content.

III. Result

3.1 Visual inspection

A visual inspection of CCA concrete cubes showed a deepening in greyish colour with increasing CCA content. This could be because CCA is naturally grey. Also, concrete cube specimens cured in the aggressive environments showed an increase in surface deterioration with increasing CCA proportion. Cubes with 0 % CCA content had the lowest surface deterioration while those with 20 % CCA content had the highest. Similarly, a whitish surface was observed for samples cured in sodium sulphate solution, probably because of the formation of gypsum on the cube surface. Furthermore, a part of the binder/cement paste was dissolved from the surface and edges of the cubes during curing in the chemical solutions.

3.2 Weight loss

Table 2: Shows that weight loss increased with increasing percentage replacement of CCA in the samples. It can also be seen that samples with 0 % CCA had the lowest weight loss while samples with 20 % CCA recorded the highest weight loss. The reason for this trend could be because of the eroding of hydrated cement and also due to the reduced quantity of binder/cement and increased CCA proportion. Finally, it was observed that samples immersed in sulphuric acid solution recorded the highest weight loss while those immersed in sodium hydroxide had the lowest; this could be due to the alkaline nature of cement.

Table 2: Weight loss

Identification Mark	CCA PERCENTAGE	H_2SO_4(kg)	NaOH(kg)	Na_2SO_4(kg)
M1	0%	0.2	0.1	0.2
M2	10%	0.4	0.2	0.3
M3	20%	0.6	0.4	0.5

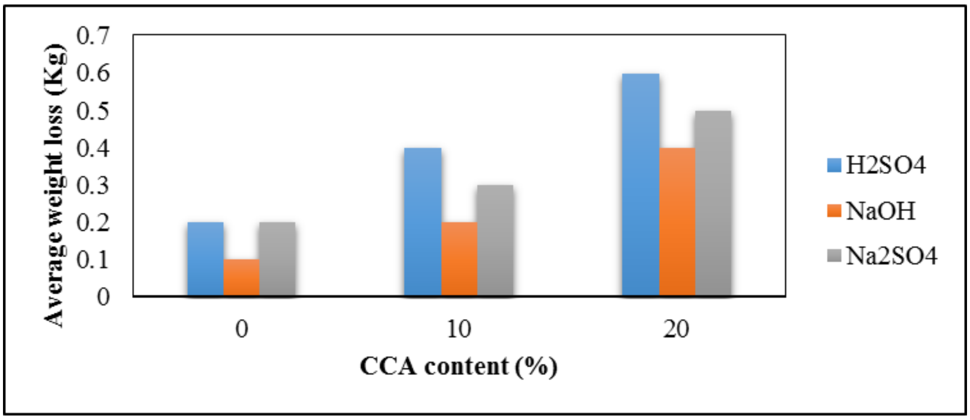

Figure 1: Weight loss of cubes cured in 5% chemical solutions

3.3 Density of cubes

Table 3: Shows the density of the cubes where D1is the density of test sample 1, D2is the density of test sample 2, D3is the density of test sample 3 and DAis the average density of the three test samples. It can be observed that density decreased as the percentage of CCA increased in the specimens. This may be because OPC has a higher specific gravity (3.15) than CCA (2.15).

Table 3: Density of samples cured in chemical solutions

CCA Content		Density of cubes kg / m^3		
		H_2SO_4	NaOH	Na_2SO_4
0 % CCA	D1	2598	2704	2687
	D2	2703	2728	2594
	D3	2520	2566	2585
	DA	**2607**	**2666**	**2622**
10 % CCA	D1	2502	2687	2654
	D2	2552	2556	2490
	D3	2410	2401	2410
	DA	**2488**	**2548**	**2518**
20 % CCA	D1	2404	2507	2397
	D2	2399	2539	2465
	D3	2130	2241	2248
	DA	**2311**	**2429**	**2370**

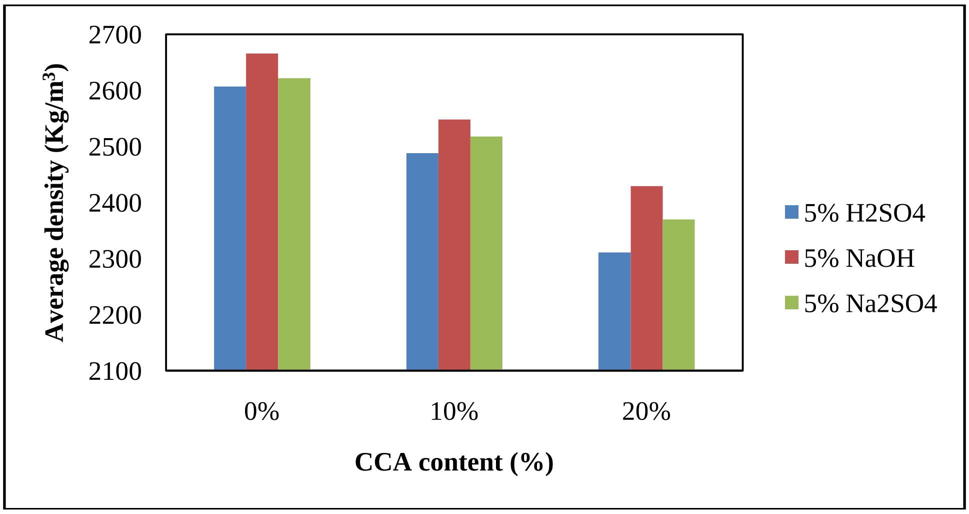

Figure 2: Density of cubes versus CCA percentage

3.4 Compressive Strength

Table 4: Shows the compressive strength result for samples soaked in 5 % of the different aggressive media for 90 days. Where Fcu_1 is the compressive strength of test sample 1, Fcu_2 is the compressive strength of test sample 2, Fcu_3 is the compressive strength of test sample 3 and Fcu_A is the average compressive strength of the three test samples. It can be observed that the compressive strength generally decreased with increasing CCA percentage. For samples with equal CCA content, compressive strength was higher in cubes cured in water than those immersed in the chemical solutions (acid, alkali and sulphate). Besides, compressive strength for CCA concrete samples cured in alkali and sulphate were close while samples immersed in acid recorded the lowest values.

Table 4: Compressive strength of test samples

CCA Content		Compressive Strength (N / mm^2)		
		H_2SO_4	NaOH	Na_2SO_4
0 % CCA	Fcu_1	16.8	25.9	20.2
	Fcu_2	9.6	21.4	29.5
	Fcu_3	18.6	29.2	32.8
	Fcu_A	**15**	**25.5**	**27.5**
10 % CCA	Fcu_1	13.6	23.1	25.1
	Fcu_2	13.7	24.7	21.3
	Fcu_3	7.2	17.3	14.2
	Fcu_A	**11.5**	**21.7**	**20.2**
20 % CCA	Fcu_1	10.5	15.43	14.3
	Fcu_2	10.4	15.52	15.5
	Fcu_3	10.6	15.55	14.9
	Fcu_A	**10.5**	**15.5**	**14.9**

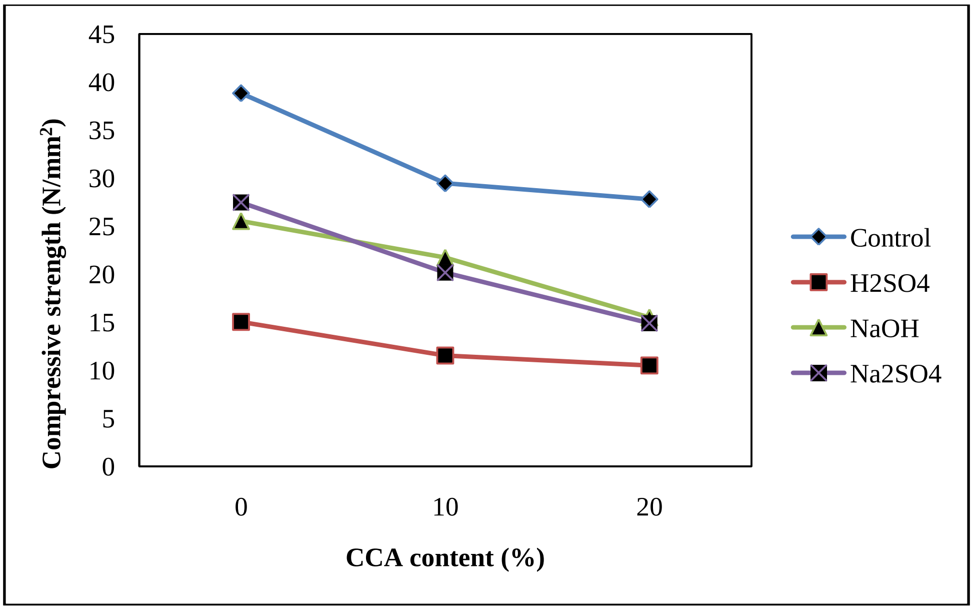

Figure 3: Comparison of compressive strength of concrete cured for 90 days in 5% chemical solutions

3.5 Regression Models for Compressive Strength

Table 5: Shows the plotted experimental values for compressive strength of cube specimens cured in the different media for 90 days and regression models generated equations for each plot. Ninety days compressive strength was computed from the regression equations and these values are compared with actual observed experimental values. It can be observed that the computed values from the regression equations closely agree with the experimental values.

Table 5: Computed values for average crushing strength from regression equations and experimental results

Curing media	Regression equations	From regression equations (N / mm^2)			Experimental values (N / mm^2)		
		0%	10%	20%	0%	10%	20%
H_2SO_4	y = -22.5x + 14.583	14.6	12.3	10.1	15	11.5	10.5
NaOH	y = -50x + 25.9	25.9	20.9	15.9	25.5	21.7	15.5
Na_2SO_4	y = -63x + 27.167	27.2	20.9	14.6	27.5	20.2	14.9
WATER	y = -49x + 32.167	32.2	27.3	22.4	33.2	25.2	23.4

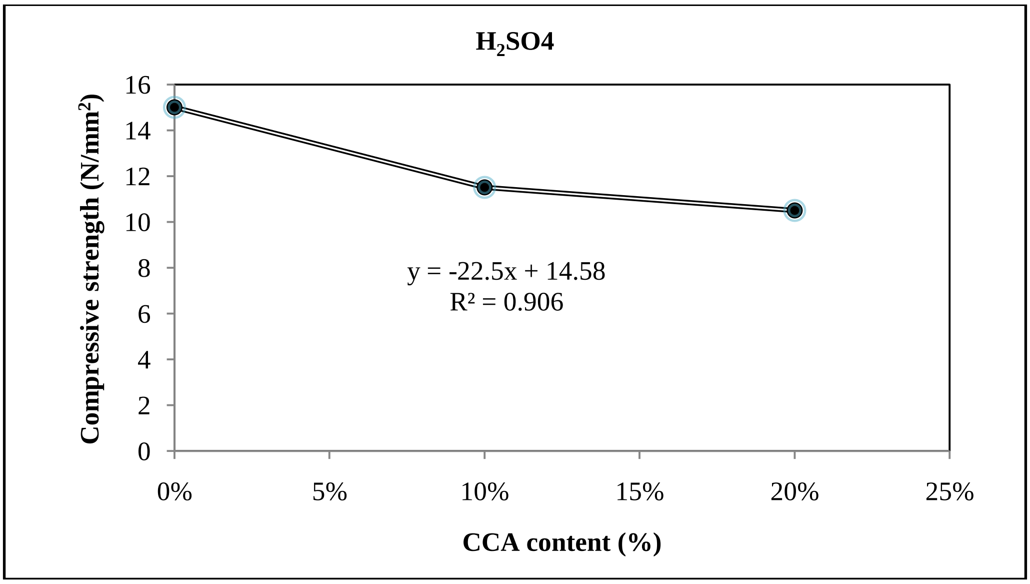

Figure 4: Compressive strength of CCA concrete cured for 90 days in 5% sulphuric acid solution

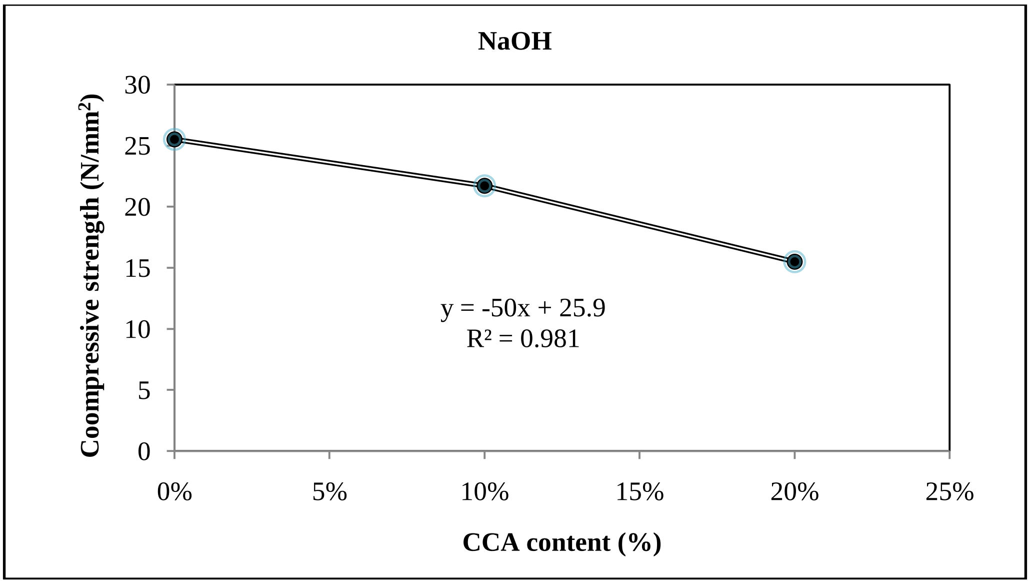

Figure 5: Compressive strength of CCA concrete cured for 90 days in 5% sodium hydroxide solution

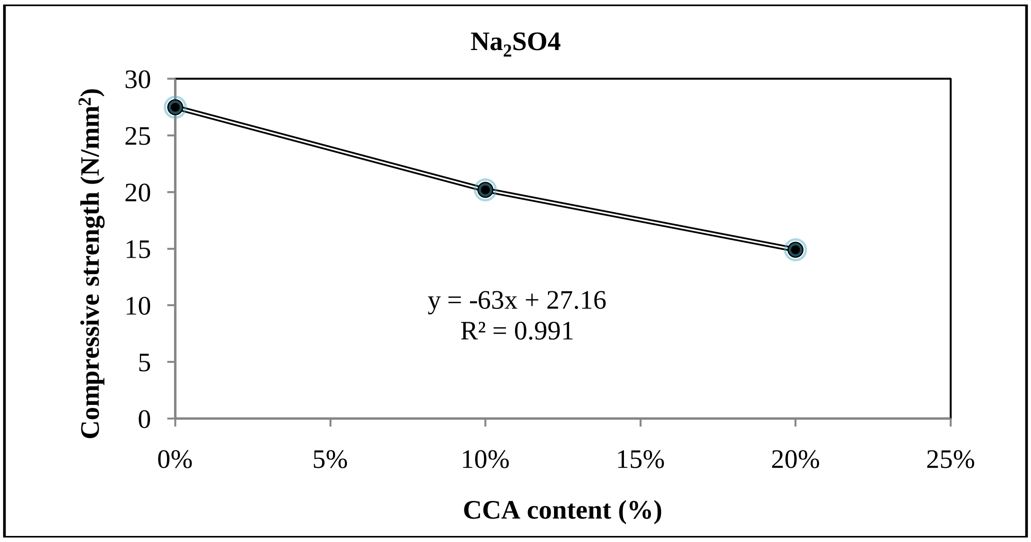

Figure 6: Compressive strength of CCA concrete cured for 90 days in 5% sodium sulphate solution

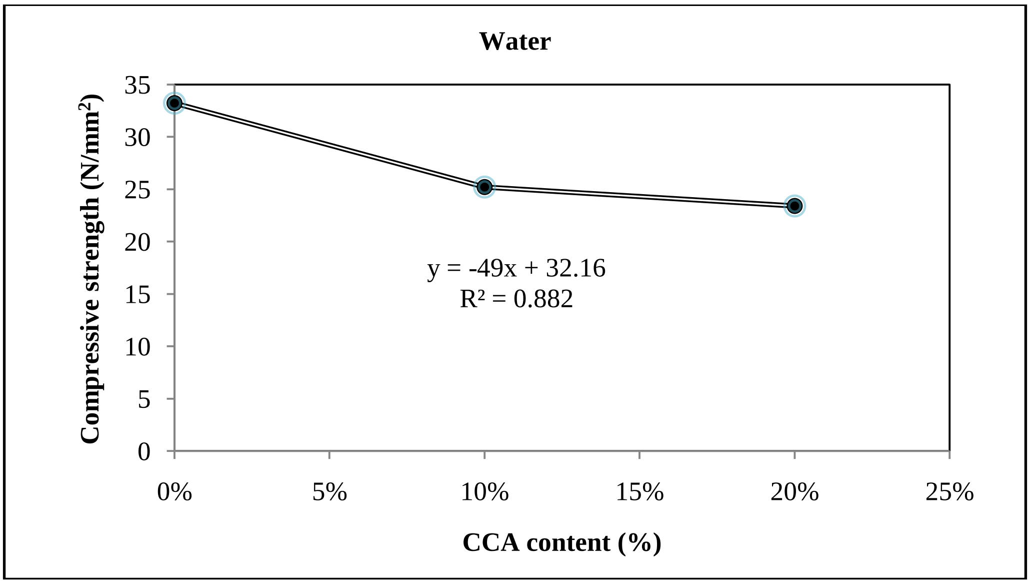

Figure 7: Compressive strength of CCA concrete cured for 90 days in water

IV. Conclusion

The following conclusions were drawn from the study:

1. In acid, alkali and salt solutions, weight loss of samples increases with increasingCCA percentage.
2. Surface deterioration of samples increases with increasing CCA percentage in each of the chemical solutions.
3. Cubes cured in water had the highest compressive strength while those cured in acid solution had the lowest for same age and CCA percentage.

Recommendations

In order to establish a clear trend on the influence of chemical attack on CCA concrete, further studies should be done from 0 - 30 % replacement in steps of 5 %, while samples should be allowed to cure for 360 days and tested every 60 days.

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