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INVESTIGATION ON THE POTENTIALS OF CUPOLA FURNACE SLAG ASH AS PARTIAL REPLACEMENT FOR CEMENT IN CONCRETE STRUCTURES

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ABSTRACT:

The compressive strength of the concrete designed using blast cupola furnace slag and granulated cupola slag as a coarse aggregate and partial replacement for cement was investigated. A series of experimental studies were conducted involve concrete production in two stages. The first stage comprised of normal aggregate concrete (NAC) produced with normal aggregates and 100% ordinary Portland cement (OPC). Meanwhile, the second stage involved production of concrete comprising of cupola furnace slag an aggregates with 100% ordinary Portland cement (OPC) and subsequently with 2%, 4%, 6%, 8% and 10% cementitious replacement with granulated cupola furnace slag that had been grounded and milled to less than 75 µm diameter. The outcomes of compressive strength test conducted on the slag aggregate concrete (SAC) with and without granulated slag cementitious replacement were satisfactory compared to normal aggregate concretes (NAC). Keywords: Cupola furnace slag, compressive strength, normal aggregate concretes, slag aggregate concrete

INTRODUCTION

The dominant role of pure Portland cement is slowly decreasing in favour of substituted and composite cements. A very important development in our modern times is the steadily growing amount of substitutes such as industrial by-products, wastes, and unprocessed materials. These substitutes can be employed in the production of cements and concrete which make it possible to optimize the concrete durability in service (Johannes, H.P, 2012).. The understanding and the use of metallurgical slag which constitute a majority of wastes from metallurgical processes is one of the promising developments. The

use of industrial by-products features not only as a partial solution to environmental and ecological problems, but it also significantly improves the microstructure and consequently the durability properties of concrete, which has been found difficult to achieve by the use of pure Portland cement [4]. It has been verified that the substituted of blended cements or the cements based entirely on waste products, can provide performance properties that are better than or not found in Portland cement.

MATERIAL AND METHOD

Cupola furnace slag

The blast cupola furnace slag was obtained from the foundry shop located at the lite industrial estate in Kano, and brought here in kaduna polytechnic, where the total volume was split into two parts. The first part was crushed using Jaw crusher and a Pulverizer to sizes of less than 20 mm diameter in accordance with the mix design. The crushed slag need to be passed through 19 mm diameter sieve before being used as coarse aggregates. The second part was first dusted and isolated to remove visible earth impurities. It was then pulverized to less than 4 mm diameter sizes and was afterward ballmilled to achieve the powdered granulated form of the slag. A final process of sieving through 75 µm sieve was carried out before it can be used as partial replacement for cement in the production of concrete.

Properties of materials

The properties of the fine, crushed rock aggregate and Cupola furnace slag are as presented in Table 1. It can be clearly understand from the fineness modulus, specific gravity and bulk density that the materials exhibit good qualities as recommended by BS812: Part101 (1985)

Table 1 Summary of materials properties.

	River Sand	Crushed Rock	Cupola Slag
Fineness Modulus	2	5.9	
Specific Gravity, Gs	2.9	3.2	2.9
Bulk Density (kg/m3)	1468	1470	1450

ASTM 33. West Conshohocken, United States, (2013).

3.0 RESULTS AND DISCUSSION

Table 2 : Compressive Strength of Control, 5%, 10% and 15% (Grade 20)

Age (Days)	**Crushing strength (N/mm^2)**			
	Control	5% Repl.	10% Repl.	15% Repl.
7	14.00	11.67	10.24	9.00
14	21.00	19.67	16.67	11.13
21	21.33	22.33	21.00	12.00
28	28.33	23.00	22.33	13.43

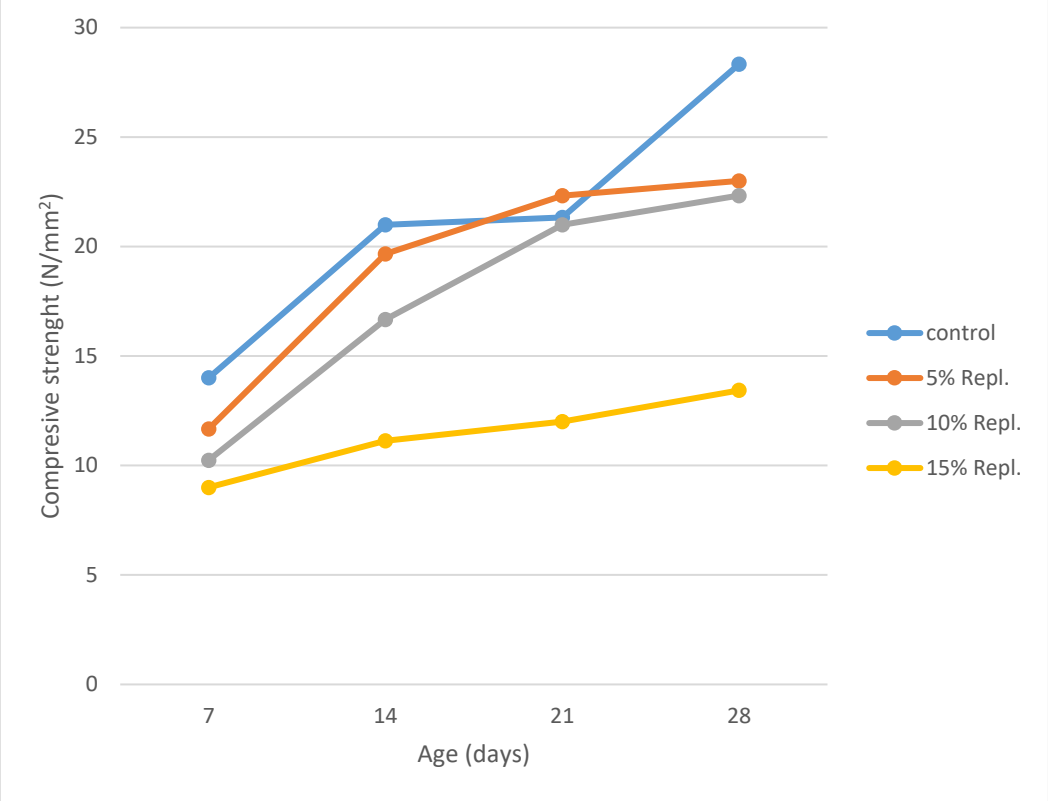

Fig.1 A graph of compressive strength (N/mm^2) against Age (Days) for Grade 20

Table 2. compressive strength of control, 5%, 10% and 15% (Grade 25)

Age (Days)	**Crushing strength**		**(N/mm^2)**	
	control	5% Repl.	10% Repl.	15% Repl.
7	18.67	16.84	10.58	9.58
14	22.1	19.98	11.59	11.59

21	28.74	23.68	21.97	12.64
28	30.4	25.25	24.38	13.38

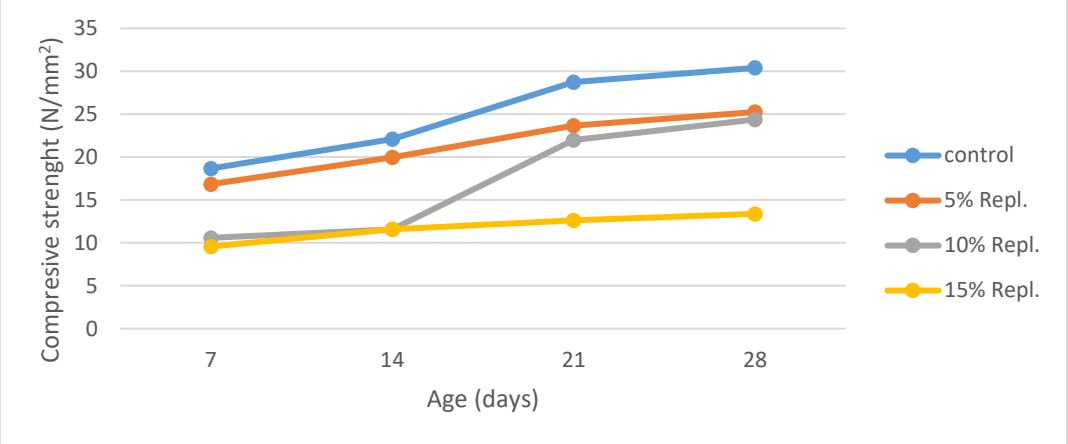

Fig.2 A graph of compressive strength (N/mm^2) against Age (Days) for Grade 25

Table 3. compressive strength of control, 5%, 10% and 15% (Grade 30)

Age (Days)	**Crushing strength (N/mm^2)**			
	control	5% Repl.	10% Repl.	15% Repl.
7	18.67	16.84	10.58	9.58
14	22.1	19.98	11.59	11.59
21	28.74	23.68	21.97	12.64
28	30.4	25.25	24.38	13.38

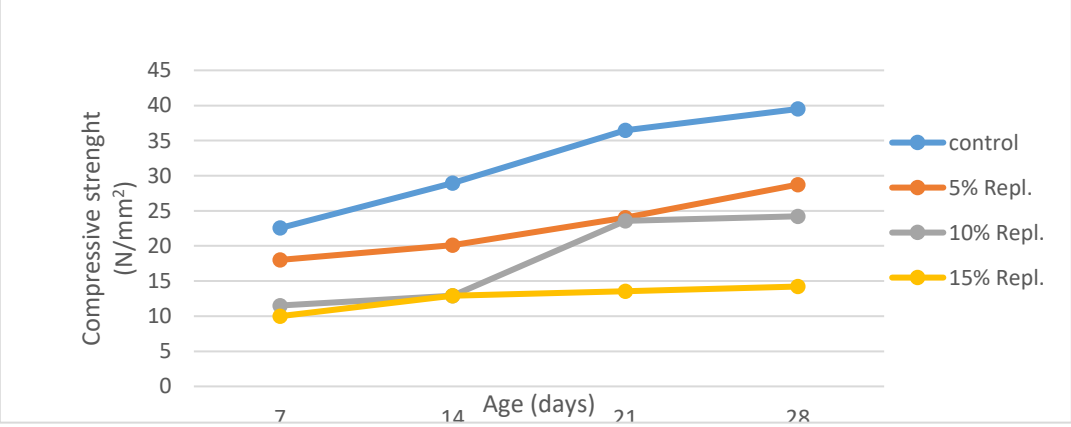

Fig.3 A graph of compressive strength (N/mm^2) against Age (Days) for Grade 30

DISCUSSION OF RESULT

The result obtained from the entire test carried out on the sample of concrete is as follows:

The result of Compressive Strength for Control, 5% and 10 % replacement in Grade 20, 25 and 30 are as follows: For Grade 20 at 7, 14, 21 and 28 days are, Control mix: 14.00, 21.00, 21.33 and 28.33 N/mm2, 5% replacement: 11.67, 19.67, 22.33 and 23 N/mm^2, 10% replacement: 12.83, 21.67,22 and 23.33 N/mm2, 15% replacement: 9.00, 11.13, 12.00 and 13.43 N/mm^2. For Grade 25 at 7, 14, 21 and 28 days are, Control mix: 18.87, 22.85, 28.85 and 30.53 N/mm^2, 5% replacement: 16.67, 19.71, 22.98 and 25.11 N/mm^2, 10% replacement: 10.95, 12.03, 16.27 and 19.73 N/mm^2, 15% replacement: 9.58, 11.59, 12.64 and 13.38 N/mm^2. For Grade 30 at 7, 14, 21 and 28 days are, Control mix: 22.55, 28.95, 36.50 and 39.29 N/mm2, 5% replacement: 16.34, 18.43, 24.01 and 2.74 N/mm^2, 10% replacement: 10.52, 10.90, 11.57 and 12.22 N/mm^2, 15% replacement: 10.00, 12.90, 13.57 and 14.22 N/mm^2 respectively.

The results of this trend may be due to a drop in workability with increase cupola slag. test to assess the workability of fresh concrete indicates that incorporation of cupola slag in concrete leads to a decrease in slump value, which depends on the cupola slag content. this reduction in slump was due to the absorption of some quantity of mixing water by cupola slag particles.

Because of the large surface area of cupola slag, 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 using cupola slag would have been considered a light-weight concrete.

CONCLUSION

From the result obtained in this study, it can be concluded that cupola slag ash can be used as a potential material for replacing cement. There is an increase in strength with increase in curing age, a decrease in strength with an increase in percentage replacement of the cupola slag ash

RECOMMENDATIONS

The results of this study have shown a significant reduction in compressive strength of concrete utilizing cupola slag than normal concrete, it could be recommended that cupola slag concrete should be used in road curbs, concrete

blocks, non-bearing concrete walls, precast units (partition walls, concrete blocks for Architectural applications and some cases of slabs on soil, culverts, sidewalks, drive ways), foundation pads for machinery, etc. it is here by recommended that further study should be carried out under proper supervision on the cupola slag in concrete by the addition of admixtures such as silica fume and sodium hydroxide at different percentage in other to overcome the significant reduction of concrete strength due to replacement with cupola slag

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