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EFFECT OF CARBIDE WASTE ON THE PERFORMANCE OF BLENDED CEMENT CONCRETE AGAINST FIRE

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ABSTRACT

Ordinary Portland Cement (OPC) Concrete deteriorates considerably when exposed to certain aggressive environment such as fire or elevated temperature. The addition of certain materials obtained from agricultural and industrial wastes to OPC concrete could improve its performance in these environments. This paper investigated the effect of Carbide Waste (CW) on the compressive strength of concrete when exposed to fire. This was achieved by partially replacing OPC with 10 percent (%) of CW to produce 150 x 150 x 150 mm 30 concrete cubes. Sample of 100% OPC were also produced which served as the control. The quantities of cement, fine aggregate and coarse aggregate used for the research were obtained through absolute volume method of mix design. Water/cement (w/c) ratio of 0.65 was adopted for the two specimens. The specimens produced were cured in ordinary water for 28 days after which they were heated in a furnace at varying temperatures of 200, 300, 400, 600, and 800^{o}C. Specimens were heated for 2 hours at each testing temperature to achieve the thermal steady state after which their compressive strengths were determined. It was found that after increase in compressive strength of the control specimen up to 300^{o}C, the concrete suffered severe loss in compressive strength with further increase in temperatures up to 800^{o}C. However, the compressive strength of the blended cement concrete increase with increase in temperature up to 500^{o}C and then, decrease with further increase in temperatures. Replacement of OPC by 10% CW increases concrete resistance to fire by 14% of OPC concrete.

***Keyword:* Blended, Cement, Carbide, Concrete, Fire and Performance.**

INTRODUCTION

Concrete is a construction material composed of Portland cement and water combined with sand, gravel, crushed stone, or other inert material such as expanded slag or vermiculite (Orchard, 1973). The major constituent of concrete is aggregate which may be natural (gravel or crushed rock with sand) or artificial (blast furnace slag, broken brick and steel shot). Another constituent is binder which serves to hold together the particles of aggregate to form concrete. Commonly used binder is the product of hydration of cement, which is the chemical reaction between cement and water (Orchard, 1973). Admixture may also be added to concrete mixes to change some of its properties. CW in this study is the admixtures.

ASTM C 260 defines the term admixture as a material other than water, aggregates, hydraulic cement, and fiber reinforcement, used as an ingredient of a cementitious mixture to modify its freshly mixed, setting, or hardened properties and that is added to the batch before or during its mixing. There are different types of admixtures. There are chemical admixtures which are materials that are added to the constituents of a concrete mixture, in most cases, specified as a volume in relation to the mass of the cement or total cementitious materials. The admixtures interact with the hydrating cementitious system by physical and chemical actions, modifying one or more of the properties of concrete in the fresh and/or hardened states. ASTM C 414 stated that chemical admixtures are used to enhance the properties of concrete and mortar in the plastic and hardened state. These properties may be modified to increase compressive and flexural strength at all ages, decrease permeability and improve durability, inhibit corrosion, reduce shrinkage, accelerate or retard initial set, increase slump and workability, improve pump ability and finish ability, increase cement efficiency, and improve the economy of the mixture. Chemical admixtures are also frequently used to accelerate, retard, improve workability, reduce mixing water requirements, increase strength, improve durability, or alter other properties of the concrete.

The air-entraining admixtures are primarily used to stabilize tiny air bubbles in concrete, produced by mixing, and protect against damage from repeated freezing-and-thawing cycles. Entrained air should not be confused with entrapped air.

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entrainment is usually the result of an addition of a liquid admixture to the concrete during batching, but y be obtained by using cement blended with a powdered admixture. As a result of the mixing action, se admixtures stabilize air bubbles that become a component of the hardened concrete. The resultant air-id system consists of uniformly dispersed voids throughout the cement paste of the concrete. These tiny ids (between 10 and 1000 micrometers in diameter) must be present in the proper amount and spacing to effective at providing freezing-and-thawing protection. Concrete made with fine aggregate that is cient in the smaller particle sizes may benefit from air entrainment.

W is the remnant of the oxy-acetylene gas used in welding industries to join pieces of metal by the road de panel beaters and it is whitish in color. The whitish color material which was regarded as waste and narily posed environmental nuisance in terms of its unpleasant and unsightly appearance in open-dump es located at strategic places within the societies can now be considered as binder in partial replacement expensive, unaffordable or unavailable cement if dried in the sun in an open for a period of one week, inded and then sieved to cement fineness. Dauda, (2006) investigated the strength properties of concrete sing CW as partial replacement of OPC and observed that the compressive strength of concrete increased in W content of an amount up to 10% replacement level of OPC and decreased with further percentage crease. Abalaka (2007) investigated the performance of bricks stabilized with CW and observed preciable increase in compressive strength of the bricks over the control bricks (bricks stabilized with her form of waste materials). The partial replacement of OPC with CW in concrete production should be a welcome development in Nigeria considering its major benefits in the area of cost reduction in rural construction, increasing manufacturing activities and reducing the need for imported materials. The cost of CW/OPC concrete is very low compared to that of OPC concrete but there is need to ascertain the performance of this concrete when exposed to aggressive environment such as fire or elevated temperatures since Neville and Brooks (2002) opined that the effect of increase in temperature on the strength of concrete is not much up to a temperature of about 250°C but above 300°C, definite loss of strength takes place and that hydrated hardened concrete contains a considerable proportion of free calcium hydroxide ($Ca(OH)_2$) which loses its water above 400°C leaving calcium oxide (CaO). If this CaO gets wet or is exposed to moist air, rehydrates to $Ca(OH)_2$ accompanied by an expansion in volume. This expansion disrupts the concrete. In the light of this, the study therefore, focused essentially on the compressive strength of concrete made with CW as partial replacement of cement if expose to aggressive environment such as fire or elevated temperature (Neville, 1996).

MATERIALS AND METHODS

The Research work was carried out at building laboratory of Ahmodu Bello University Zaria. The CW used for the research work was obtained from road side panel beaters within Zaria Local Government in Kaduna State of Nigeria. The CW was grinded by grinding machine and then sieved with 75µm BS sieve. Only those that passed through this 75µm sieve were used for the research work. Ordinary Portland Cement (Dangote brand), naturally occurring clean sharp river sand and coarse aggregate obtained from a small quarry along Samaru-PZ near school of Aviation Technology Zaria, sieved with 10 mm and 20 mm sieve sizes to get rid of the suspended and organic impurities were used for the research. To assess the suitability of CW as partial replacement of OPC in concrete production, Seventy five (75) trial mix with absolute volume method of mix design in ratio 1:2:4 was first carried out at varying percentage (%) replacement level of 0, 5, 10, 15 and 20% at different water/cement (w/c) ratio varying from 0.5 to 0.7. The essence of this was to determine the appropriate w/c ratio that would give the highest strength in concrete which was finally adopted for the research. The 0% specimen served as the control. Water/cement ratio of 0.65 was finally adopted for the production of the final specimens. Ninety concrete cubes (90) were prepared for the final specimens. The specimens were cured in ordinary water for 28 days after which they were heated in a furnace at varying temperatures of 200, 300, 400, 500, 600 and 800°C. Specimens were heated for 2 hours at each testing temperature to achieve the thermal steady state after which their compressive strengths were determined. The preparation of the test specimens follows the procedure as outlined by appropriate British Standards especially BS 1881: 124 (1988) and BS 1881: 125 (1986). In the process of the research, standard test according to British Standard specifications such as soundness, workability and setting time were also carried out.

RESULTS AND DISCUSSION

Physical Properties of Materials

Setting Time Test

Table 1: Setting Time of CW Concrete

%CW	Cement (g)	CW (g)	Water (ml)	Initial Setting Time (hrs)	Final Setting Time (hrs)
0	800	0	120	1.30	5.10
5	380	20	130	2.25	6.30
10	360	40	134	2.50	6.55
15	340	60	152	3.00	7.10
20	320	80	174	3.20	7.30

As it can be observed in table 3, the time required for CW/OPC past to harden increase with increase in the CW replacement for both the initial and final setting times. This shows that the CW has influence on the setting time.

Soundness Test

Table 2: Result of Soundness Test for CW Concrete

Carbide Content (%)	Sample A (mm)	Sample (mm)	Average Value (mm)
0	1.3	1.3	1.3
5	1.3	1.5	1.4
10	1.6	1.6	1.6
15	1.8	1.8	1.8
20	1.6	2.0	1.8

The expansions of the specimens were less than 10 mm specified by BS 12:2: 1971. This confirmed that the cement and CW used for the research are of good quality. It was also clear that increase in CW content lead to increase in soundness of the pastes. For OPC without CW, the expansion was 1.3 mm. With increase in CW content there is an increase in soundness up to 10% replacement and then decrease with additional increase in CW.

Workability Test

Table 3: Result of Workability Test for CW Concrete

CW	W/c Ratio	Degree of Workability			
		Slump (mm)		Compacting Factor	
0	0.65	8	Low	0.85	Low
5	0.65	7	Low	0.86	Low
10	0.65	6	Low	0.86	Low
15	0.65	6	Low	0.87	Low
20	0.65	4	Low	0.88	Low

The result of workability test using slump test method shows that the slump was within the range of 4-8 mm, this shows that the degree of workability was low. (ASTM 1881: Part 2:1970).The result of the compacting factor test on the samples also indicates low workability (Orchard, 1973).The compacting factor test on the samples fall between the range of 0.85 – 0.92 recommended by Orchard (1973) for roads and slabs concretes.

Table 4 Chemical Analysis of CW and OPC

Constituents	CW (%)	OPC (%)
Calcium Oxide (CaO)	64.79	72.70
Silica Oxide (SiO_2)	20.93	11.00
Aluminium Oxide (Al_2O_3)	4.40	3.20
Ferrous Oxide (Fe_2O_3)	3.49	3.87
Magnesium Oxide (MgO)	1.19	2.05
Sulphur Oxide (SO_3)	2.10	2.9
Potassium Oxide (K_2O)	0.13	0.73
L.O.I	2.70	1.20
Moisture Content	3.76	1.05

...m the result of chemical analysis, the CW used in the study does not satisfy the requirement of ASTM C ...-1978 for Pozzolanas, since the summation of the percentage composition of silica oxide (SiO_2), ...minium Oxide (Al_2O_3) and Iron Oxide (Fe_2O_3), is 28.82% which is less than 70% specified by the code.

...mpressive Strength Tests

...ble 5: 28 Days Compressive Strength of Specimens in Ordinary Water

Carbide Waste Content (%)	Water Cement Ratio	28 Days Compressive Strength (N/mm²)			Average
0	0.65	25.58	25.62	25.60	25.60
5	0.65	22.10	23.00	22.32	22.47
10	0.65	24.42	24.60	24.86	24.63
15	0.65	19.46	20.80	20.22	20.19
20	0.65	16.42	18.92	18.46	17.93

...e results of the compressive strength of concrete cubes as partial replacement of CW between 5 to 15% ...mplied with BS 8110(1985) which states that the minimum compressive strength required for concrete to ...e used for structural purpose at 28 days should be between 20 -40N/mm.[2] The.

...ompressive Strengths of Specimens at Varying Temperatures

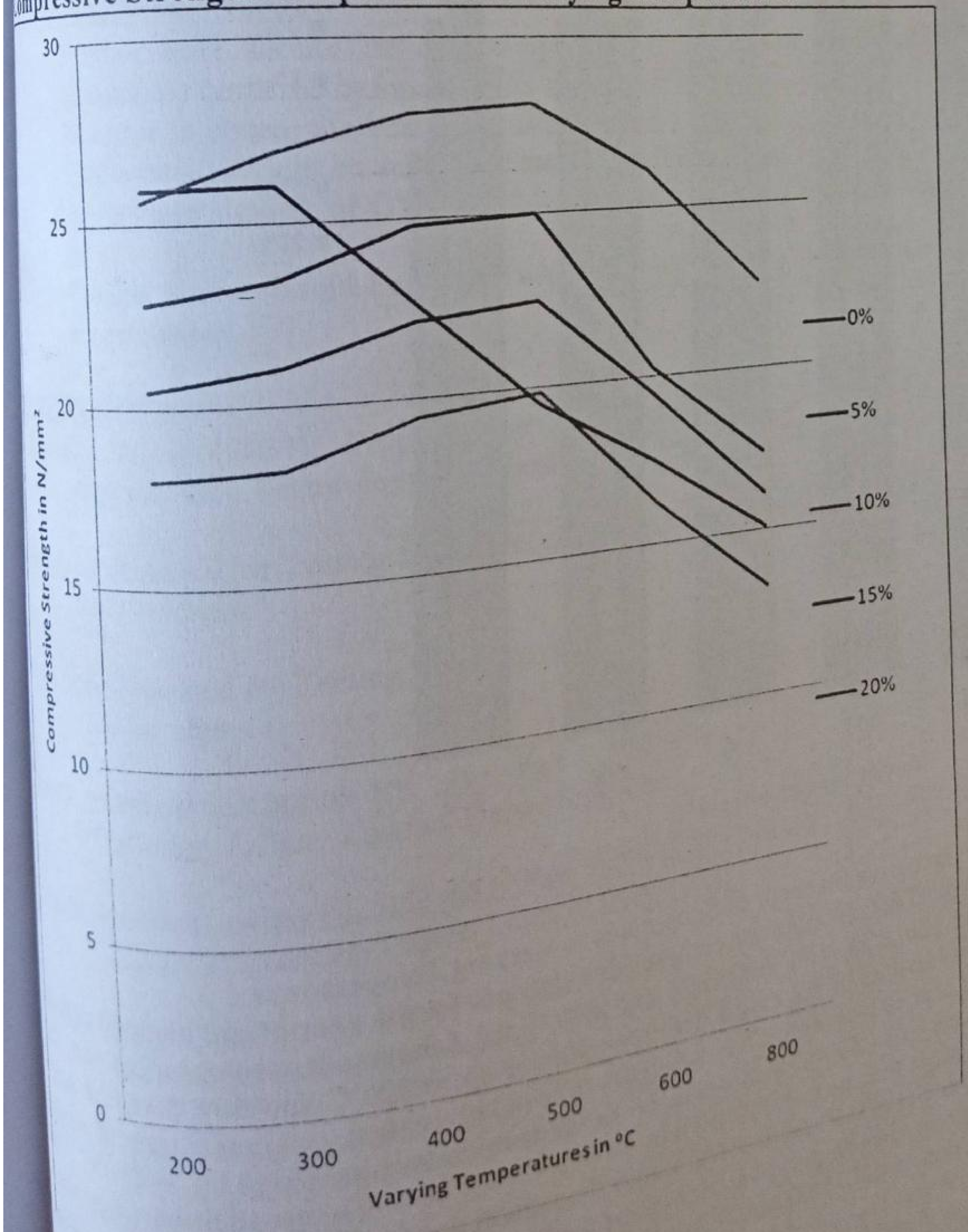

Figure 2: Line Graph of the Compressive Strength of Specimens at Varying Temperatures

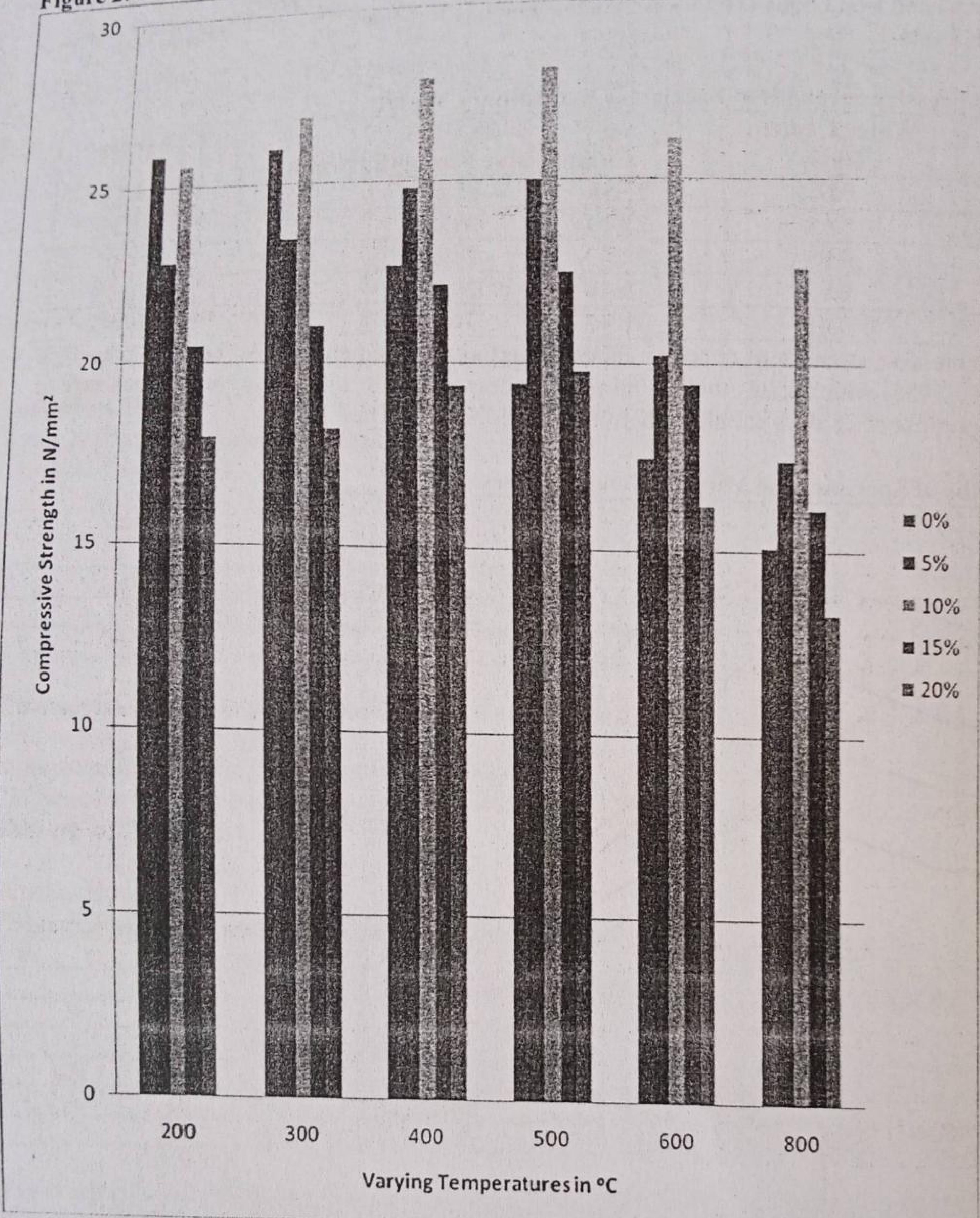

Figure 3: Bar Graph of the Compressive Strength of Specimens at Varying Temperatures

Figure 2 and 3 illustrate the typical development of compressive strength for the control and blended cement concretes thermally treated at 200, 300, 400, 600, 500 and 800°C for 2 hours. It was observed that the compressive strength of control specimen increased with temperature up to 300°C and then decrease up to 800°C. It was also observed that the compressive strength of blended cement concrete increase as the treatment temperature increased up to 500°C then decrease as the temperature increased up to 800°C. The increase in compressive strength in the control specimen up to 300°C may be due to the additional hydration of un hydrated cement grains as a result of steam effect under the condition of so called internal autoclaving effect (Neville, 1981). The increase in compressive strength of the blended cement concrete specimens up to 500°C may be due to the reaction of the admixture (CW) with the free lime to produce more CSH and CAH which deposit in the pore system. The compressive strength of the control started to decrease at 300°C whereas those of the blended cement started to decrease at 500°C. This phenomenon is contributed to higher volume of CSH and CAH phases formed in the blended cement concrete on the one hand and reduction in $Ca(OH)_2$ contents on the other hand relative to those developed in control specimen. Cement matrix with higher volume of gel-like hydration products, and lower crystallic $Ca(OH)_2$ contents has improved fire

...nce (Neville and Brooks, 2002). The decrease in compressive strength with temperature may be due to ...hydration of the Ca (OH) $_2$ at about 600°C producing CaO and H_2O. Over 700°C strength loss are ...y caused by calcium carbonate dissociation and subsequent CO_2 escaped from $CaCO_3$. Strength losses ...ss in blended cement concrete in comparison to the control. This is contributed to lesser Ca (OH) $_2$ ...nts found in blended cement concrete because of the admixture reaction consuming free lime ...usable for Ca (OH) $_2$ formation, and hence for easy carbonation to $CaCO_3$ (Shetty, 2005).

...NCLUSIONS AND RECOMMENDATIONS

...clusions

...d on the test conducted, the following conclusions were drawn:

That the Carbide Waste (CW) performs satisfactorily as partial replacement of OPC in concrete if the proportion of the CW is kept at 10 %.

The compressive strength of CW concrete compares favorably with that of control in ordinary water at 28 days.

Soundness of cement increase as CW content increase.

Replacing OPC with 10% of CW would increase the fire resistance of the concrete by14% of OPC concrete at 500°C.

...COMMENDATIONS

Further tests should be carried out on tensile and flexural strengths of CW concrete and be adequately certified before used for reinforced concrete construction.

In order to obtain the best result from CW as a local partial replacement of cement in concrete, the CW content should be accurately measured which should be 10% of the cement used.

Appropriate sieving of CW should be done after grinding in order to guide against impurities in the mix.

Further study should be carried out on the performance of CW concrete in chemically aggressive environment.

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