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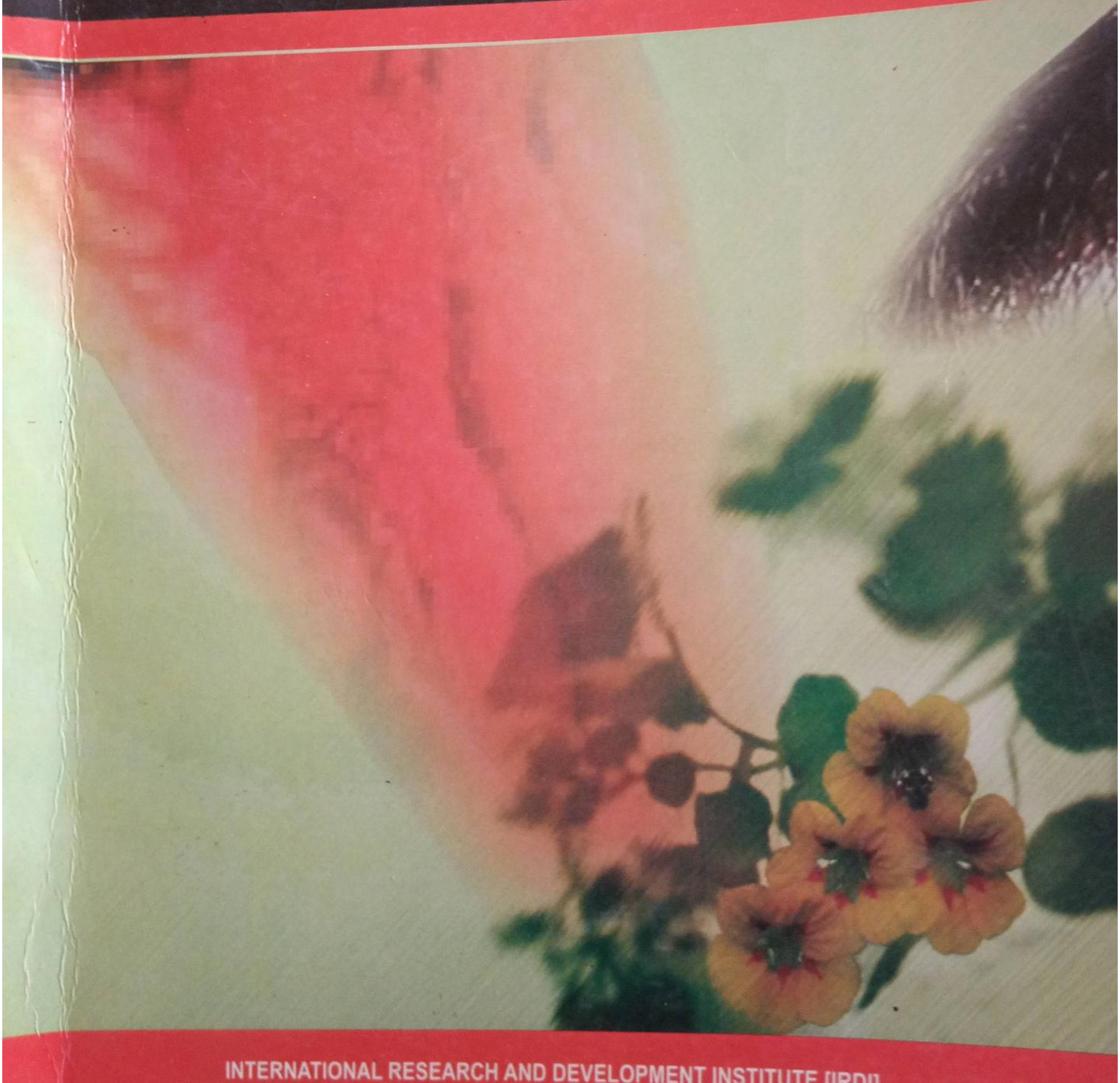

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INTERNATIONAL RESEARCH AND DEVELOPMENT INSTITUTE

RESEARCH AND DEVELOPMENT NETWORK

PROCEEDINGS OF THE ANNUAL CONFERENCE

THEME:
RESEARCH AND SUSTAINABLE DEVELOPMENT OF THE THIRD WORLD: OVERCOMING EXCLUSION, STRENGTHENING INCLUSION

A. AKA
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STRENGTH AND DURABILITY CHARACTERISTICS OF CONCRETE PRODUCED WITH BOTTLE CORK AS COARSE AGGREGATE

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ABSTRACT

The high cost of conventional building materials such as coarse aggregate in developing countries like Nigeria has led to a lots of researches in the area of how locally available Industrial and Agricultural wastes can be used to partially or fully replaced coarse aggregate in concrete production. This paper investigated the strength and resistance to thermal shocks of concrete produced with Bottle Cork (BC) as coarse aggregate. This was achieved by producing concrete cubes by fully replaced Crush Granite (CG) with BC through absolute volume method of mix design having a mix ratio 1:2:4 (cement: sand: BC (coarse aggregate for the control)). Water/cement ratio of 0.6 was adopted for the research. Eighteen (18) concrete cubes were produced for BC specimen and 18 for the control. The specimens produced were heated at temperature of 300°C for 40 minutes after curing in water for 28 days and then quenching in water for 5 minutes (1st cycle). The cycle was repeated until cracks or damage was observed on the specimens. The same procedure was also repeated for varying temperatures of 600 and 900°C. The result shows that replacing CG with BC in concrete production would lead to reduction in thermal shocks resistance of the concrete by 3 cycles. The research therefore, recommends BC as alternative material to CG in production of concrete but the concrete should not be exposed to elevated temperature up to 900°C.

Keywords: Aggregate, Bottle Cork, Characteristics, Durability and Strength.

INTRODUCTION

Durability of Portland cement is defined as it ability to resist weathering action, abrasion, attack by fire, aggressive chemicals or any other process of deteriorations. In other words, cement concrete will be termed durable when it keeps it form and shape within the allowable limits while exposed to different environmental conditions (Zelie et.al, 2000). In the past, only strength of concrete was considered in concrete mix design procedure assuming that strength of concrete was an over all pervading factor for all other desirable properties of concrete including durability. This opinion was proved wrong in the late 1930s when they found that series of failures of concrete pavements had taken place due to environmental frost attack. Although compressive strength is a measure of durability to a great extent, it is not entirely true that the strong concrete is always a durable one (Shetty, 2005). In addition to strength of concrete other factors such as environmental condition (weather), elevated temperature, sudden shocks and aggressive chemicals have become an important consideration for durability (Neville, 1981). Meriam Webster (2006) defines environmental weather as the meteorological conditions, including temperature, precipitation and wind that characteristically prevail in a particular region. Neville and Brooks (1996) have extensively researched on concrete in hot weather and cold weather conditions.

Shetty (2005) opined that abrasion is an external factor that has a great deteriorating effect on concrete durability and it has been observed as the wearing away of the surface of the concrete by friction therefore, concrete used in roads, floors and hydraulic structures if durable should equally exhibit resistance against abrasion. Although, the resistance against abrasion is closely connected with the compressive strength of concrete i.e. the more the compressive strength, the higher the resistance to abrasion. According to Neville and Brooks (2002) the fire resistance of concrete structure is determined by three main factors: the capacity of the concrete itself to withstand heat and the subsequent action of water without losing strength unduly, without cracking or spalling; the conductivity of the concrete to heat and the coefficient of thermal expansion of concrete. 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. 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 (Neville, 1981).

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Adewuyi and Ola (2005) opined that Civil engineering practice and construction works in Nigeria depend a very large extent on concrete and concrete is one of the major building materials that can be delivered the job site in a plastic state and can be molded in-situ or precast to virtually any form or shape. Its ba constituents are cement, fine aggregate (sand), coarse aggregate (granite chippings) and water. Hence, overall cost of concrete production depends largely on the availability of the constituents. Although aggregate is readily available, the cost of cement can be reduced through the use of pozzolanas (Elinwa Mahmood, 2002; Oyetola and Abdullahi; 2006; Dahiru and Zubairu; 2008). The cost of concrete is direc proportional to the cost of crushed stones or local gravels, which increases from the north to the south. Th alternatives lightweight materials are adopted for non-load bearing walls and non-structural floors buildings. Some of these alternative materials include palm kernel shell, olive seed and periwinkle she which can be used to fully or partially replace coarse aggregate in concrete production (Okpala 1990; Ekai 1991; Falade (1995) and Job (1994). Ndoke (2006) assessed the performance of palm kernel shells as parti replacement for coarse aggregate in asphalt concrete, while Falade (1992) investigated the suitability palm kernel shells as aggregates in light and dense concrete for structural and non-structural purposes. Oth similar efforts in the direction of waste management strategies as coarse aggregate in concrete producti include structural performance of concrete using Oil palm shell (OPS) as lightweight aggrega (Falade,1992). Little or no research exists on the strength and durability (resistance to thermal shock) concrete produced with Bottle Cork (BC) if used as coarse aggregate.

BC is abundantly available in every nook and cranny of our environments. It serves as nothing but cover the bottle that contains the soft drink Malta gold or coca cola until the drink is set for consumption. The co is immediately thrown away the moment is removed on the bottle and serves no further use but constitutes problem of wastes disposal to the societies. Despite the availability of BC in the world and Nigeria particular; with a lot of established research findings on the suitability of many Agricultural and Industri wastes as alternative materials in concrete production little or no effort has been made toward the utilizati of BC. The use of BC in production of concrete would not only reduce the problem of Industrial wastes the societies but would greatly reduce the cost of concrete production. It is in the light of this that th research investigated the strength and durability characteristics of BC concrete by producing concrete cub with the use of BC as coarse aggregate, cured in water for 28 days to determine its compressive strength an then, tested its resistance to thermal shock.

RESEARCH HYPOTESIS

i Does BC in question possess the required properties of coarse aggregate.
ii What effect would BC have on the strength and durability characteristics of hardened concrete.
iii Would the existing relationship between compressive strength and resistance to thermal shock fo coarse aggregate concrete be applicable and valid for BC concrete.

MATERIALS AND METHODS

Materials: The materials used for the research work were obtained within Birnin Kebbi in Kebbi Sta Ordinary Portland Cement (OPC (Dangote brand)) was used for the experiment. The fine aggregate (sharp sand) used for study was obtained from a flowing river, dried for some days in th laboratory and then sieved to be free from deleterious materials. Crushed granite was purchased from quarry site and BC was obtained in sufficient quantities from the environments. The BC was collected wi the help of the available students in the department of Building Technology Waziri Umaru Feder Polytechnic for a period of one week before the required quantity for the research was obtained. They we locally bent in the laboratory to compress their shapes which could increase their strength performance concrete production. Ordinary clean tap water free for drinking was used for the experiment.

Mix Proportions and Casting of Concrete Cubes:

Batching operation by volume approach was adopted in the study. Preliminary mixes of 1:2:4 (cement: fin sand: BC (coarse aggregate for the control)) was investigated with water/cement ratio of 0.55, 0.60, 0.65 an 0.70 respectively so as to obtain the required w/c ratio for the actual mixes. W/c ratio of 0.6 was adopted fo the actual mix design (BC and the control). Concrete mix were properly mixed in a machine mixer for abo six to eight minute and then cast into 150 × 150 × 150 mm^3 size concrete mould. Concrete cubes were mad in accordance with BS 1881: (1985). Eighteen (18) concrete cubes were produced for BC specimen and fo for the control. The specimens produced were left in the mould for 24 hours after which they were remove and completely immersed in water for 14, 21 and 28 days hydration periods. At each hydration perio specimens were weighed before testing and the densities of cubes were measured. Prior to testing, th specimens were brought out of the water, left outside in the open air for about 2 hours before crushing. The compressive strengths of the cubes were tested in accordance to BS 1881: (1983) with the use of universal testing machine.

The thermal shock resistance of the specimens were determined by heating the specimens after 28 days hydration in ordinary water for 40 minutes at varying temperature (300, 600 and 900°C) followed by quenching in water for 5 minutes at each testing temperature (Mohamed and Sayed, 2006). The process was repeated for each temperature until the specimens were broken or damaged.

RESULTS AND DISCUSSION

Physical Properties of Materials Used for the Research

Table 1: Physical Properties of BC, Crushed Granite (CG) and River Sand

S/No	Properties	Sample type and descriptions		
		BC	CG	River sand
1	Specific Gravity	1.82	2.66	2.56
2	Compacted Bulk Density (kg/m3)	528	1486	1680
3	Loose Bulk Density (kg/m3)	434	1274	1458
4	Water Absorption (%)	0.40	0.60	0.40
5	Moisture Content (%)	0.24	0.32	0.06
6	Porosity (%)	0.32	0.8	0.04
7	Impact Value (%)	9	13	-

The Bulk Density test carried out on the samples of materials (BC, CG and River sand) used for the research was in accordance with the provisions of BS 812: Part 2: (1975). The results are shown in Table 1. The ratio of the loose bulk density to the compacted bulk density of BC was observed to be 0.82. This value is close to value specified by the code which is between 0.87 and 0.96 as reported by Neville and Brooks (2002).The specific gravity of the materials was determined in accordance with the requirement of BS 812: Part 2: (1975).The specific gravity of BC was observed to be 1.82. This is close to the values recorded by Neville and Brooks (2002) for natural aggregate which is between 2.6 to 2.7. The water absorption of BC, CG and the sand used for the research was obtained in according to the provision of BS 812: Part 2: (1975) and the water absorption of BC was observed to be 0.40. The value obtained is less than the value obtained by Job (2008) on periwinkle shell which was found to be 7.18 and also compared favorably to the value obtained on the CG used for the research. Porosity is the volume occupied by void to the volume of the material. It is usually expressed in percentage (Neville 1981). The porosity of BC was found to be 0.32%. The value obtained was less than that of CG used for the research. The impact values of materials sample was carried out in accordance with the provision of BS 812 Part 110 (1990) and was obtained to be 9%. This is close to 13% obtained on the CG used for the research. The test is needed when dealing with aggregate of unknown performance (Neville and Brooks, 2002).

Workability Test

Table 2: Workability of the Pastes (1:2:4 Mix Ratio)

S/No	Concrete Sample	W/c Ratio	Degree of workability	
			Slump (mm)	Compacting factor
1	BC	0.6	8	0.75
2	CG	0.6	6	0.78

The slump test on BC and CG samples were observed to be 8 and 6 mm respectively which indicates low workability (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 two samples is close to the range of 0.85 – 0.92 recommended by Orchard (1973) for roads and slabs concretes.

Compressive Strength and Density Tests

Table 3: Average Compressive Strengths and Densities of Specimens in Ordinary Water at 14, 21 and 28 Days (1:2:4 mix at 0.6 w/c ratio)

Concrete Specimens	Compressive strengths (N/mm^2)			Average density (Kg/m^3)		
	Days			Days		
	14	21	28	14	21	28
BC	12.50	18.55	20.60	2340.38	2350.52	2396.88
CG	14.30	20.80	26.44	2410.45	2418.00	2461.28

The results of densities and compressive strengths of concrete specimens (BC and CG) in water at 14, 21 and 28 days hydration are presented in Table 3. From the results, significant difference in compressive strengths and densities of the specimens in water were observed at each hydration period. The densities of the two specimens in ordinary water at 28 days are within the range recommended for normal weight concrete which is between 2355 to 2560 kg/m^3 (Everett,1990). The two concrete specimens attained the minimum compressive strength recommended by BS 8110 (1995) for structural concrete at 28 days which between 20-40 N/mm^2. Increase in strength was observed in the two specimens at 21 and 28 days in water.

Resistance to Thermal Shocks of Specimens

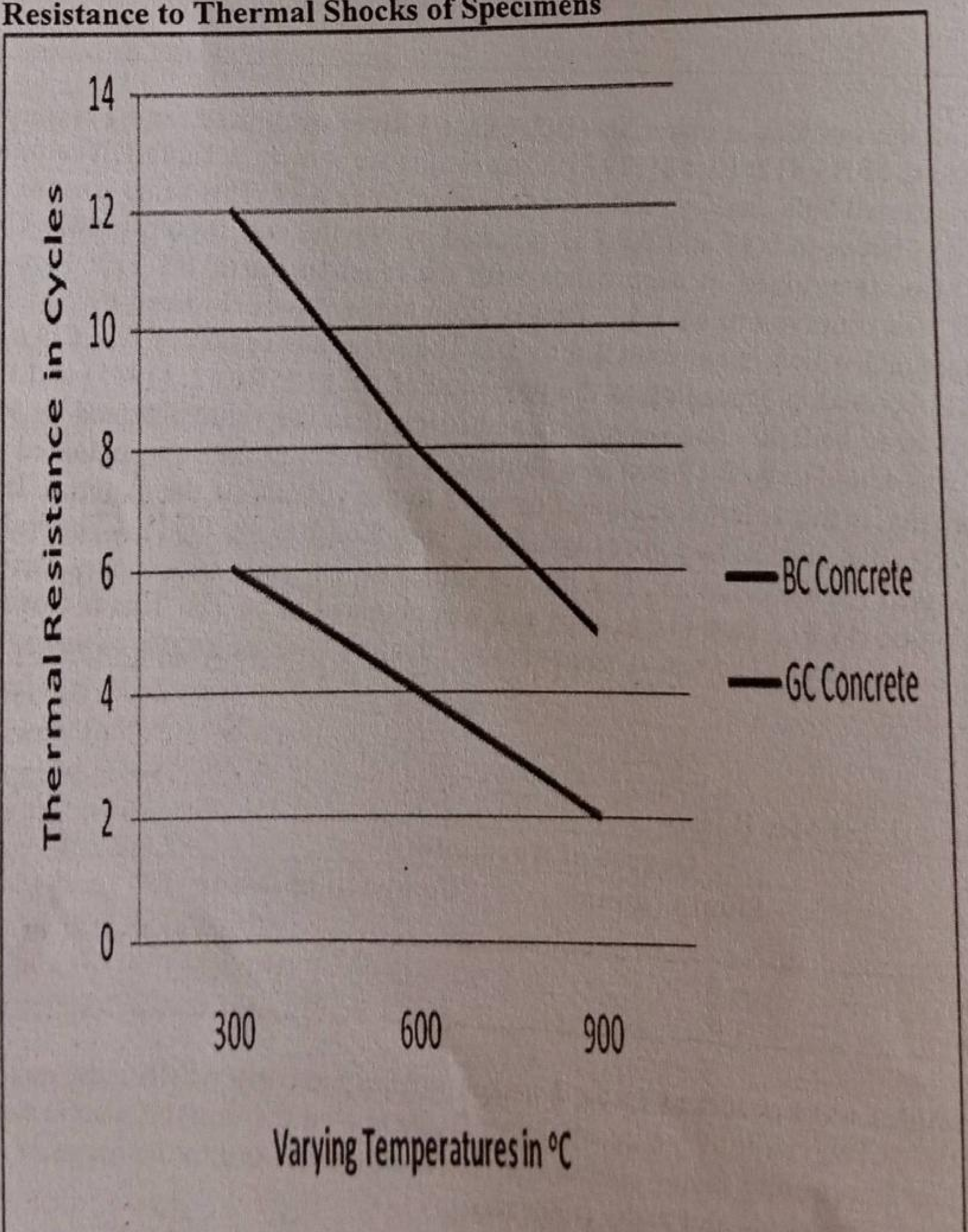

Figure1: Line Graph of Resistance o Thermal Shock of Specimens in Cycles

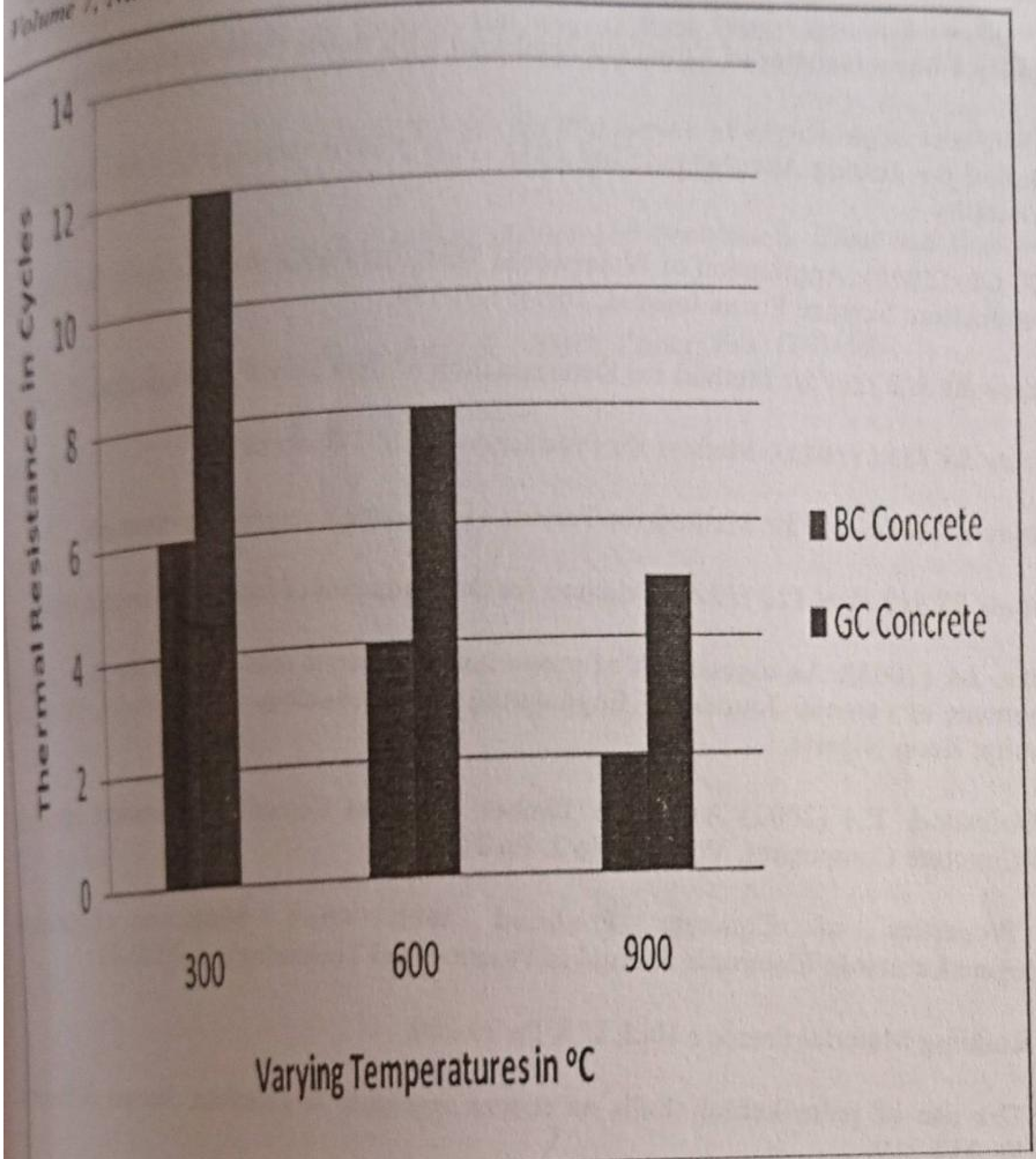

Figure 2: Bar Graph of Resistance to Thermal Shocks of BC and CG Concretes at Varying Temperatures

The effect of BC on the thermal shock resistance of concrete is shown in figure 1 and 2. During heating, the outer layers of the specimens tend to expand more than the inner layers. Subsequent sudden cooling would unbalance the internal equilibrium, with significant internal stresses developed as the outer layers attempt to contract relative to the inner layers. The differential deformation between the different layers leads to crack activities (Neville, 1981) consequently; at 300°C the BC specimen could resist 6 cycles thermal shock before cracks developed while CG specimen could resist 12. At 600°C, BC concrete resisted 4 cycle thermal shocks while CG resisted 8 and at 900°C BC concrete resisted 2 cycles thermal shocks while CG resisted 5. Replacing CG with BC in concrete production would lead to reduction in thermal shock resistance of the concrete by 3 cycles at 900°C.

CONCLUSIONS

There was significant different in the compressive strength of BC concrete when compared to that of CG concrete at 28 days hydration in ordinary water. The thermal shock resistance test carried out on BC concrete also shows that BC concrete has lower resistance to thermal shocks in comparison to CG concrete at different temperatures. Hence, the work concluded that replacing CG with BC in concrete production would lead to reduction in thermal shock resistance of the concrete by 3 cycles at 900 °c.

RECOMMENDATION

BC is recommended as alternative material to crushed granite in production of light weight concrete. The work recommends that BC concrete should not be used for production of concrete that would be exposed to fire. Further studies should be carried out to determine the durability of BC concrete in aggressive chemicals and other forms of deleterious environment such as hot weather.

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