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TEMPERATURE EFFECTS ON GROUNDNUT SHELL ASH CONCRETE

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Abstract

The effects of groundnut shell ash on concrete and its fire resistance capabilities were studied. One hundred and eighty four (184) blended concrete samples were carried out dosed with 5 %, 10 % and 15 % groundnut shell ash in weighted percentages. Curing were done and the blended concrete were evaluated at 7 days, 28 days, 30 days, 60 days, 90 days, 120 days, 150 days and 200 days respectively. Exposure of the blended samples to temperatures of 100º C, 200 º C, 300 º C, 400 º C, 500 º C, 600 º C and 700 º C in a muffle electric furnace for the duration of 2 hours were carried out.

It was reported that an increase of compressive strength was observed, beyond the control's concrete between 90 days and 200 days of curing for the 5 % by weight of GSA blended concrete. The 5 % by weight of groundnut shell ash concrete and control concrete fire resistance ranged between (60 %-81.4 %) for (200 ºC-400 ºC), (36.5 %-40.9 %) at 500 ºC, and (17.2 %-22.3 %) for (600 ºC-700 ºC). The 5 % by weight of GSA concrete may have a good prospect in harsh and hazardous environment not exceeding 100 ºC when cured up to 200 days period.

***Keywords*:** groundnut shell ash, temperature, blended concrete, compressive strength

Introduction

High temperature can affect concrete and its properties dramatically [1]. High temperatures mean temperatures usually above 100ºC [2]. Buildings on fire may experience temperatures between 100ºC to 1100ºC and even up to 1350ºC in tunnels, leading to severe damages in a concrete structure [3]. Ordinary Portland cement (OPC) products are generally regarded as good structural materials with respect to fire resistance that is, the period of time under fire during which concrete continues to perform satisfactorily [4]. The importance of fire resistance effect on structural concrete is required, to preserve some structural actions over a desired length of time known as fire rating usually for one hour duration [5]. However, there is a need to source for local material like groundnut shell ash that can be added to concrete to preserve these structural actions beyond the normal one hour duration.

Groundnut shell is an agricultural waste obtained from milling of groundnut. About 5% of ash is obtained when the shells are oxidized by burning [6]. Researchers have been reporting the use of agro-waste ashes as pozzolanic materials in concrete. Alutu and Ufuah [7] studied palm fibre ash, maize husk ash and maize cob ash. Otunyo [8] studied palm kernel husk ash as an admixture (accelerator) in concrete. Olafusi and Olutoge [9] studied 'strength properties of corn cob ash concrete. Raheem et al. [10] also studied 'saw dust ash as partial replacement for cement in concrete'. These aforementioned works have revealed that these agricultural waste ashes contain high amount of silica in amorphous form and could be used as pozzolanic materials [11].

The improved properties of blended cement concrete as well as the reduction of environmental problems in the society are as a result of the utilization of pozzolans. However, the inclusion of ground nut shell ash as an agricultural waste to further improve the resistance of concrete exposed to higher temperatures can contribute to the fire resistant properties of structures. Numerous research on concrete exposed to fire have been ongoing, however the focus has been on the exposure time of one hour duration [12]. The groundnut shell ash concrete exposure to high temperatures for two hours will be the focus of this study.

Materials and method

Research Design

The materials include groundnut shell ash, ordinary Portland cement, 20 mm crushed coarse aggregate, fine aggregate and water. Steel moulds (100 mm x 100 mm x 100 mm size), shovel, head pans and muffle electric furnace were the tool used in the test. Groundnut shells materials were discovered at Jattu town, Etsako West Local Government Area in Edo state. The preparation of the groundnut shell material followed the procedure by appropriate standards [13].

The blended cement concrete specimens of 100 mm x 100 mm x 100 mm concrete sizes created one hundred and eighty four (184) concrete specimens at 5 %, 10 % and 15 % in weighted percentages for the groundnut shell ash (GSA) replacement with OPC. The control concrete and the GSA concrete specimen were cured by immersion for 7 days, 28 days, 30 days, 60 days, 90 days, 120 days, 150 days and 200 days respectively and crushed to obtain their compressive strength readings according to BS 1881: Part 124 methodology{14} . The duration of curing period was adopted because the Pozzolan-lime reactions are usually slow, starting after one or

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more weeks [15]. The specimen cured at 200 days were exposed in a controlled environment (muffle furnace) to varying temperatures from 100ºC to 700ºC for two (2) hours duration using the unstressed residual strength test method according to ASTM E119-00 methodology [16]. The 200 days cured specimens were chosen due to its higher compressive strength obtained when compared to the control concrete. After which the specimen were removed from the furnace and allowed to cool to room temperature. The specimens were taken to the compression machine to determine the residual compressive strength. The laboratory tests conducted enable us to collect data. The tests includes the chemical analysis of ground shell ash (GSA) and ordinary Portland cement (OPC), specific gravity test, bulk density test, compressive strength test and temperature test.

Results and Discussion

Chemical analysis of ground shell ash (GSA) using x-ray fluorescent method

The results show that GSA contains most of the compounds known to have binding properties necessary for concrete work. However, GSA has total iron oxide (Fe_2O_3), silicon dioxide (SiO_2) and aluminum oxide (Al_2O_3) percentages were 43.87%, which are less than the required minimum ASTM C618 standard [17].

Sieve Analysis Test

Figure 1 shows the result of the sieve analyses carried out according to ASTM C136 methodology [18].

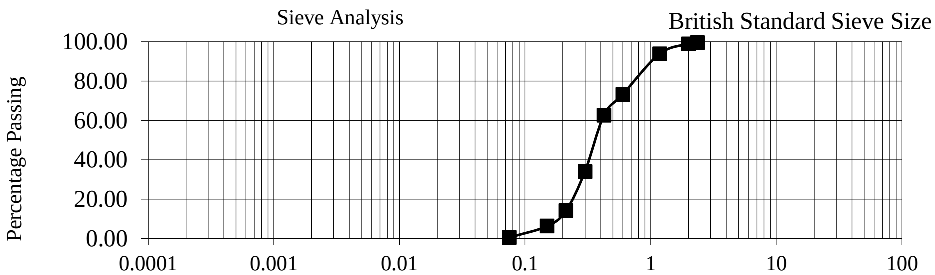

Figure.1: Particle size Analysis for Fine Aggregate

Specific Gravity Test

The minimum standards of ASTM C127 methodology [19] were followed during the performance of specific gravity test. The GSA material had result of 0.84 which was lesser than 3.15, the value for OPC. This means that OPC is heavier than GSA.

Densities of the Binary Blended Concrete

Table 1 reported the densities of the GSA blended concrete and the test was carried out according to ASTM C642 methodology [20]. There was an increase in densities as duration of curing increased for OPC concrete. Subsequently, a decrease for 5 % to 15 % by weight of GSA concrete between 30 days to 90 days was observed. However an increase of density was observed at 200 days of curing for 5 %, 10 % and 15 % by weight of GSA concrete more than the control's concrete density. These may be due to the GSA filling the pores in the concrete which may result to its increased density when compared to OPC concrete.

Table 1: Density of the GSA blended concrete

Age of Curing (Days)	Densities (Kg/m^3)			
	Percentage of GSA (wt %)			
	0% wt (OPC)	5% wt (GSA)	10% wt (GSA)	15% wt (GSA)
30	2375	2375	2330	2260
60	2360	2390	2355	2325
90	2390	2410	2395	2340
120	2400	2430	2410	2350
150	2385	2445	2370	2345
200	2365	2450	2535	2485

Compressive strength of the GSA concrete

There was a progressive increase of compressive strength for all categories of the GSA blended concrete as the curing duration increases as shown in Table 2 and Figure 2 respectively. The weighted percentage of 5 % GSA blended concrete compressive strength increase started at 30 days to 200 days of curing with a compressive strength of 18.0 N/mm^2 to 23.3 N/mm^2 above the compressive strength of the control concrete. This represents 1.06 % of compressive strength increase of 5 % GSA concrete over control concrete compressive strength when cured up to 200 days. This depicts what Ettu [21] said about pozzolanic concrete that below 50 days, strength development is below control concrete but above 50 days to 90 days strength improves beyond control concrete. For the weighted percentages of 10 % and 15 % GSA blended concrete there was increases in compressive strength but less than the control concrete's compressive strength at 200 days curing period.

This was corroborated by [22].

Table 2: GSA and OPC compressive strengths and curing ages at 23ºC

Age of Curing (Days)	Compressive Strength (N/mm²)			
	5% by weight of GSA	10% by weight of GSA	15% by weight of GSA	Normal concrete (OPC)
7	7.6	6.4	5.5	9.4
28	13.1	12.1	11.7	14.1
30	18	16.0	12.5	16
60	18.5	16.5	14.0	16.5
90	19.5	16.5	15.0	18.5
120	21.0	17.5	16.0	18.5
150	22.1	17.8	19.0	19.5
200	23.3	19.1	21.8	22

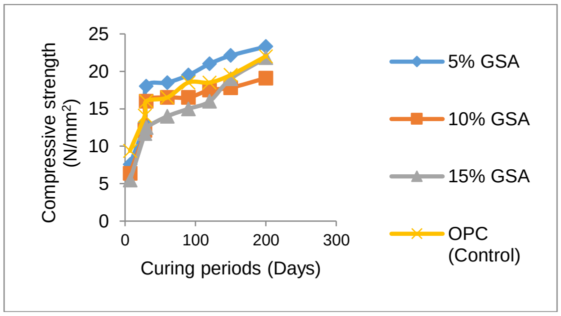

Fig 2: A graph showing compressive strength and curing period at 0%-15% GSA replacement

The effect of temperature on the GSA blended concrete

The progression of decrease in compressive strength of the GSA blended concrete cured for 200 days as the temperature increases are shown in Table 3 and Figure 3. The 5 % by weight of groundnut shell ash concrete and normal concrete fire resistances varies between (60 %-81.4 %) for (200 ºC-400 ºC), (36.5 %-40.9 %) at 500 ºC, and (17.2 %-22.3 %) for (600 ºC-700 ºC). More than half of the compressive strength of GSA concrete were at 500 ºC while it's load bearing capacity above 600 ºC. This behaviour of concrete at high temperatures was reported by Khoury [23] that between 600ºC and 800ºC, the Calcium Silicate Hydrate decomposes therefore loses the load bearing capacity of the concrete.

Table 3: GSA concrete residual compressive strength and temperature cured at 200 days

Temperatures (ºC)	**Residual compressive strength for 200 days curing duration (N/mm²)**			
	5% by weight of GSA	10% by weight of GSA	15% by weight of GSA	Normal concrete
23	23.3	19.1	21.8	22.0
100	21.2	18.5	19.0	20.9
200	19.3	17.5	18.0	19.2
300	12.5	10.5	11.5	18.5
400	9.1	7.4	8.5	17.9
500	8.5	6.9	7.8	9.0
600	4.6	3.8	4.2	5.8
700	4.0	3.3	3.5	4.9

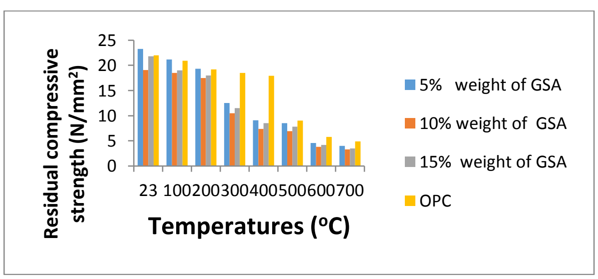

Fig 3: Residual compressive strength and temperature at 0%-15% GSA concrete cured for 200 days

Conclusion

The research can be concluded by the following findings:

1. The GSA blended cement concrete does not show good fire resistant properties at all percentages when exposed to high temperatures except at 100 ºC for 5 % GSA blended concrete when cured up to 200 days.
2. The compressive strength of the 5 % by weight of GSA blended concrete was 1.06 % increase over the normal concrete when cured up to 200 days.
3. There was an increase in the density of the GSA blended concrete as the groundnut shell ash increased in the concrete only for the GSA concrete cured up to 200 days.
4. The GSA chemical analysis has revealed that some compounds known to have binding properties necessary for concrete work are present in GSA.
5. This work have provided database for 200 days cured 5 % by weight of GSA blended concrete when exposed to fire for 2 hours.

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