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EFFECT OF GROUNDNUT SHELL ASHAND MARBLE DUST AS A PARTIAL REPLACEMENT FOR CEMENT IN CONCRETE PRODUCTION

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ABSTRACT: The need to reduce an amount of Groundnut Shell Ash and Marble Dust in an environment and possible utilization to reduce the cost of concrete production was investigated. A total number of 120 concrete cubes of size 150mm x 150mm x 150mm with different percentages replacement of Groundnut Shell Ash (GSA) and Marble Dust (MD) to Dangote Ordinary Portland Cement (OPC) at (0%, 5%, 10%, 15%, and 20%) with constant Water – Cement ratio of 0.55 were produced. Chemical Composition of Groundnut Shell Ash (GSA), Marble Dust (MD) and Dangote Ordinary Portland Cement (OPC) was examined and Slump test carried out to determine the effect of Groundnut Shell Ash (GSA) and Marble Dust (MD) on the workability of fresh concrete. A Compressive Strength at the ages of 7, 14, 21 and 28 days were determined.The results obtained from the various test carried out shows that,chemical composition of GSA has 25.4021% of ($SiO_2 + Al_2O_3 + Fe_2O_3$) which is less than 70% of compound oxides of pozzolansindicating that the sample is not in accordance with the requirements of ASTM C 618 (1991), and not a good pozzolan.The slump value decreases with percentage increase of Groundnut Shell Ash and Marble Dust. The compressive strength increases with curing age of concrete for 5%, 10% and 20%, but it decreases for 0% and 15% at 14days for mix ratio 1:2:4. Also, the compressive strength increases with age of curing at 0%, 10%, 15% and 20%, but it decreases for 5% at 14days for mix ratio $1:1^1/_2:3$. However, 10% replacement of Groundnut Shell Ash and Marble Dust with 17.34 N/mm² strength value for mix ratio 1:2:4 and 20% replacement of Groundnut Shell Ash and Marble Dust with 18.37 N/mm² strength value for mix ratio $1:1^1/_2:3$ should be adopted when replacing this admixture with cement. Since all the concrete cubes met the minimum strength of 6N/mm² after 28days of curing recommended by BS 5224 (1976) for masonry cement, Groundnut Shell Ash – Marble Dust concrete can be used for concrete works where strength is of less importance such as floor screed, mass concrete and mortar.
Keywords: shell,slump test,chemical composition,workability,compressive strength

1. INTRODUCTION

Concrete is a composite inert material that comprises of a binder (cement); mineral filler (body) or aggregate and water (Onyenuga,2008). Concrete is a very important construction material that has contributed immensely to the development of civilization. The material called concrete has seen tremendous development from high performance concrete. Concrete has immensely benefited from the usage of fly ash, Silica fumes even though it is costly, it has also enhanced the quality of concrete (Gupta and Gupta, 2008).

The need to bring down the cost of waste disposal and the growing cost of construction materials has led to intense research towards economic utilization of waste for engineering purpose. The safe disposal of industrial and agricultural waste products demands urgent and cost effective solutions because of the debilitating effect of these materials on the environment and the health hazards that these waste constitute.The over dependence on the industrial manufactured material

such as "cement" has kept the cost of construction often financially high. These hitherto have continued to deter the underdeveloped and poor nations of the world from providing good structures to meet the need of rural dwellers that constitute large percentage of their population. Thus, the possible use of agricultural and industrial waste such as "groundnut shell ash" and "marble dust" will considerably reduce the cost of construction and as well as reduce or eliminate the environmental hazards caused by such waste (Alabadanet al., 2006).

Various research workers in the recent past had look into the utilization of agricultural wastes that are known to be pozollanas to partially substitute cement that is the major component of concrete.The use of Ordinary Portland Cement (OPC) and Rice Husk Ash (RHA) concrete in minimizing thermal induced expansion cracks has been identified. This is because the OPC/RHA paste hydrates slowly and therefore evolved low heat making them suitable for use in concrete (Alabadan, et al., 2005). Rice Husk Ash (RHA) is a by-product of the agricultural industry which contains high amount of silicon dioxide (SiO_2). The tests results show that concrete incorporating RHA had higher compressive strength, splitting tensile strength and modulus of elasticity at various ages compared with that of the control concrete (Ramezanianpouret al.,2009).

Results of various test carried out by Mujeduet al., (2014), shows that the combination Corn Cob Ash (CCA) and Saw Dust Ash (SDA) are suitable materials for use as a pozzolan, since it satisfied the requirement for such a material by having a combined (SiO_2 + Al_2O_3 + Fe_2O_3) of more than 70%. Concrete becomes less workable as the percentage combination of CCA and SDA increases meaning that more water is required to make the mixes more workable. This means that the use of combination of CCA and SDA in cement to produce concrete has higher water demand. Furthermore, the compressive strength of the concrete made with CCA and SDA increases with curing ages and decreases with increased amount of the percentage combination of CCA and SDA. Only the percentage combination of CCCA and SDA up to 10% replacement of Ordinary Portland cement in concrete would be acceptable to enjoy maximum benefit of strength gain. He went further to conclude that although the strength of CCA-SDA concrete was lower than that of the control, it can still be used for general concrete work where strength is of less importance such as floor screed, mortar and mass concrete.

Maslehuddin (2011), reported that the blending of both marble dust (20-60%) and rice husk ash (10-30%) in OPC accelerates the setting as compared to control (OPC). Marble dust addition decreases the strength of OPC and the maximum of 54.5MPa has been achieved on 28days of curing with 20% of marble dust. Addition of rice husk ash increases the strength and maximum strength of 65.9MPa has been achieved with 20% of RHA blended cement.Nwofor and Sule (2010) investigated the use of considerable volume of groundnut shell ash as the partial replacement for cement in concrete production and shows that the percentage replacement of ordinary Portland cement (OPC) varies to the control (0% replacement) about 40%. The results generally show a decrease in density and compressive strength as the percentage replacement with GSA increase suggesting less hydration with cement. Based on general analysis of the result as well as the logical comparison to the acceptable standard, a percentage replacement of 10% is suggested for sustainable construction, especially in mass concrete construction.

Mahmoud et al., (2012), reported that the production of sandcrete block using Groundnut shell ash (GSA) as a partial replacement for cement shows that the compressive strength ranges from 4.50N/mm² to 0.26N/mm². The optimium replacement level by Mahmoud et al (2012) was achieved at 20% with a corresponding strength of 3.58N/mm². This also caused decreases in strength with increase of cement above 20% replacement. It was further observed that in chemical composition of the GSA as compared to cement, the amount of K_2O was higher in GSA and also CaO was less than that of cement. The research work is focused on the study of pozzolanic and non-pozzolanic effects of groundnut shell ash and marble dust in the production of concrete with various percentages of groundnut shell ash and marble dust (0%, 5%, 10%, 15%, and 20%). The drying, burning and grinding of these materials in powder (ashes) form were carried out and emphasis laid on the compressive strength test, workability, water absorption, chemical composition of groundnut shell ash and durability of the concrete as well as economy and management of the marble dust and groundnut shell ash.

2. EXPERIMENTAL PROCEDURE

Preparation and collection of materials

The materials used include groundnut shell, marble dust, cement, sand, granite and water. The groundnut shell was obtained from Arkina, Sokoto State as, while the Chemical composition

analyses on Groundnut shell ash was carried out using MV Pelletron Accelerator Machine method at Centre for Energy and Research Institute ObafemiAwolowo University Ile-Ife,Osun State. The shell was air dried for a minimum of 48 hours and burnt into ashes for two days. The marble stone was obtained in Osogbo, Osun State, and grinded to a dust State. Fine aggregate (sand) was obtained from locally available free of debris and nearby riverbed side around Federal Polytechnic Ede; the coarse aggregate (i.e. granite) of a minimum nominal size 12mm/19mm was obtained from a quarry site in Awo, Osun State and Ordinary Portland Cement (OPC) bought from a cement dealer in Ede town.

Production of concrete cubes

The combination of groundnut shell ash (GSA) and marble dust (MD) were used to replace ordinary Portland cement at 0%, 5%, 10%, 15%, and 20% by weight of cement. Concrete cube with 0% of groundnut shell ash and marble dust serve as the control experiment. A 150mm x 150mm x 150mm steel moulds was used to produce concrete cubes of mix ratios 1:2:4 and 1:1$^1/_2$:3 with constant water cement ratio of 0.55. Table 1and 2 showed the batching information for each percentage combination of GSA and MD used to replace cement for the concrete cubes cast. The cube steel moulds were assembled prior to mixing and properly lubricated with engine oil for easy removal of hardened concrete cubes. Each mould was then filled with prepared fresh concrete in three layers and each layers was tamped with taping rod using thirty-five (35) strokes uniformly distributed across the seldom of the concrete in the mould. The top of each mould was smoothened and levelled with hand trowel and then the outside surfaces cleaned. The moulds and their contents were left in the open air for 24 hours. The concrete cubes were demoulded after 24 hours of the concrete setting under air and later in storage curing tank measuring 2.0m x 6.0m filled with clean tap water only for periods of 3, 7,21, and 28 days respectively.

Table 1: Proportions of Groundnut Shell Ash and Marble Dust Concrete for 1:2:4

REPLACEMENT (%)	GROUNDNUT SHELL ASH (kg)	CEMENT (kg)	FINE AGGREGATE (kg)	COARSE AGGREGATE (kg)	WATER (Litres)	MARBLE ASH (kg)
0	—	13.890	27.77	55.54	7.63	—
5	0.695	13.195	27.77	55.54	7.63	0.695
10	1.389	12.501	27.77	55.54	7.63	1.389
15	2.084	11.806	27.77	55.54	7.63	2.084
20	2.778	11.112	27.77	55.54	7.63	2.778

Table 2: Proportions of Groundnut Shell Ash and Marble Dust Concrete for 1:1$^1/_2$:3

REPLACEMENT (%)	GROUNDNUT SHELL ASH (kg)	CEMENT (kg)	FINE AGGREGATE (kg)	COARSE AGGREGATE (kg)	WATER (kg)	MARBLE ASH (kg)
0	—	17.670	26.51	53.01	9.72	—
5	0.880	16.790	26.51	53.01	9.72	0.880
10	1.767	15.903	26.51	53.01	9.72	1.767
15	2.651	15.019	26.51	53.01	9.72	2.651
20	3.534	14.136	26.51	53.01	9.72	3.534

Table 3: Chemical Composition Value of Groundnut Shell Ash (GSA), Marble Dust (MD) and Dangote Ordinary Portland Cement (OPC)

OXIDES	PERCENTAGE COMPOSITION (%)		
	GSA	MD	OPC
MgO	4.14	0.38	2.06
Al_2O_3	0.49	0.37	5.03
SIO_2	23.25	1.38	22.00
P_2O_5	4.24	-	0.48
SO_3	-	0.24	-
K_2O	10.71	0.11	0.40
CaO	2.09	53.12	62.00
TiO_2	0.36	-	0.12
MnO_2	0.07	-	2.12
Fe_2O_3	0.78	0.28	0.60
ZnO	0.01	-	-
$CaCO_3$	-	98.00	-
LO_1	-	43.53	23.23

3. TESTING

Determination of oxidecomposition of cement, groundnut shell ash (GSA) and marble dust(MD)

Some quantity of groundnut shell ash and marble dust were taken to the laboratory (Centre for Energy and Research Institute ObafemiAwolowo University Ile-Ife,Osun State, Nigeria) and test were performed on each sample to determine their oxide composition using MvPelletron Accelerator Machine. The results are showed in Table 3 and compared with that of Ordinary Portland Cement (OPC).

Slump Test

Slump test was carried out in accordance with the requirements of BS 1881: part 102 (1983) to check the effect of GSA and MD on the workability of fresh concrete. The result is as shown in Table 4.

Compressive Strength Test

Before crushing, the cubes were brought out of the storage curing tank and kept for about 20 minutes for most of the

water to wipe off. They were later weighed on a weighing balance and then taken to the digital compression machine with maximum capacity of 1000kN in accordance with BS 1881: part 116 (1983). A Compression machine graduated in Kilo Newton (KN) was used for the determination of the compressive strength of each cube. The cubes were taken from the curing tank in sets after 7days, 14days, 21days and 28days respectively to the laboratory for crushing test. Three cubes from each percentage replacement (0%, 5%, 10%, 15% and 20%) were crushed on each days of curing and an average obtained giving an idea of the potential quality of the concrete. The concrete cubes experienced cracks due to failure in their strength as a result of the load applied by the compression machine. The compressive strength was recorded to the nearest 0.01N/mm².

Table 4: Slump Values of GSA-MD Concrete.

% Combination of GSA and MD	1:2:4					1:1½:3				
	0	5	10	15	20	0	5	10	15	20
Slump	8.50	8.50	8.00	8.00	7.00	8.50	8.50	8.20	8.10	7.00

4. RESULTS AND DISCUSSION

Chemical Composition

Table 3 shows the oxide composition of Groundnut Shell Ash and Marble Dust as compared with Ordinary Portland Cement. The result showed that Groundnut Shell Ash has 25.4021% of (SiO_2 + Al_2O_3 + Fe_2O_3) which is less than 70% of compound oxides of pozzolans indicating that the sample is not in accordance with the requirements of ASTM C 618 (1991), and not a good pozzolan.

Workability

Table 4 shows that the slump value decreases with percentage increase of Groundnut Shell Ash and Marble Dust. This is an indication that concrete becomes less workable as the percentage replacement of Groundnut Shell Ash and Marble Dust increased but on compaction factor value shows an increase with percentage increase of Groundnut Shell Ash and Marble Dust, indicating that less water – cement ratio will yield a stronger and more durable concrete when fully compacted and allowed to set.

Compressive Strength

The compressive strength of the concrete cubes for different percentages combination of GSA and MD with curing ages is shown in Table 5.

Table 5: Compressive Strength (N/mm²) of Concrete Cubes for different Percentages

% Combination of GSA, MD & OPC	Curing Ages N/mm²							
	1:2:4				1:1½:3			
	7	14	21	28	7	14	21	28
0%	8.89	8.56	12.47	20.56	8.12	9.07	10.14	18.49
5%	5.33	6.67	8.98	12.98	8.45	8.33	9.57	13.30
10%	8.45	8.33	9.57	13.33	13.83	15.23	17.40	18.37
15%	8.15	8.09	12.40	14.96	9.45	10.49	13.30	18.25
20%	7.62	7.97	10.93	15.20	13.83	15.23	17.40	18.37

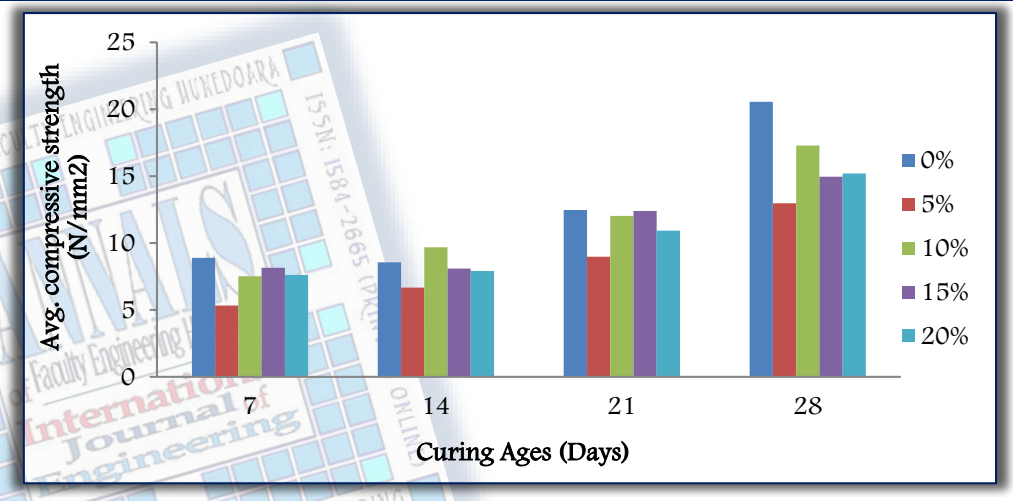

Figure 1: Effect of Curing Age on the Compressive Strength of Different Percentages Combination of GSA and MD for 1:2:4 Mix.

The relationship of the compressive strength with curing ages for different percentages of the combination of GSA and MD is also expressed graphically in Figure 1, the result obtained for 7 days of curing shows a decrease in strength from 8.89N/mm² for 0% to 7.62N/mm² at 20% for

mix ratio 1:2:4, which shows that concrete containing Groundnut Shell Ash and Marble Dust acquire strength slowly at initial curing ages. It was also deduced at 28 days that the concrete with Groundnut Shell Ash and Marble Dust percentage replacement at 10% has the highest compressive strength of 17.3N/mm² in comparison with 0% of 20.56N/mm² replacements. Indicating that concrete with Groundnut Shell Ash and Marble Dust of 10% percentage replacement can be adopted in concrete works where strength is of less importance.

In Figure 2, the result obtained for 7 days of curing shows an increase in strength from 8.12N/mm² for 0% to 13.83N/mm² for 20% for mix ratio 1:1$^1/_2$:3, indicating that concrete containing Groundnut Shell Ash and Marble Dust acquire higher strength at early curing ages over that of full OPC. It was also gathered at 28 days, that the concrete having Groundnut Shell Ash and Marble Dust percentage replacement at 20% has the highest compressive strength of 18.37N/mm² in comparison to 0% replacement of 18.49N/mm². This shows that 0% and 20% having approximately same value at 28 days, 20% percentage replacement of Groundnut Shell Ash and Marble Dust can be used for all concrete work when adopting this mix ratio.

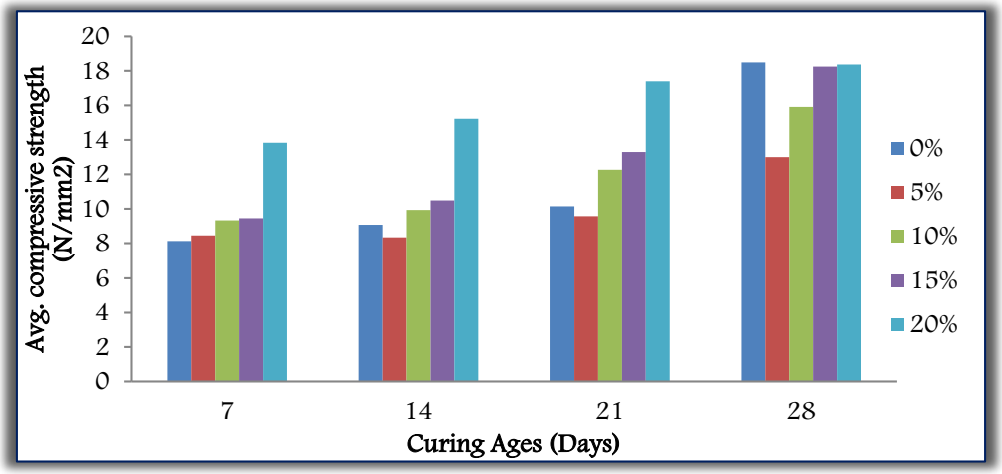

Figure 2: Effect of Curing Age on the Compressive Strength of Different Percentages Combination of GSA and MD for 1:1½:3 Mix

However, the compressive strength increases with curing age of concrete for 5%, 10% and 20%, but it decreases for 0% and 15% at 14 days for mix ratio 1:2:4. Also, the compressive strength increases with age of curing at 0%, 10%, 15% and 20%, but it decreases for 5% at 14 days for mix ratio 1:1$^1/_2$:3. There was a general increase of concrete strength with percentage replacement of Groundnut Shell Ash and Marble Dust from 5% to 20% except at 14 days and 21 days of 5% replacement and 28 days for all percentage replacement where the strength value was less than the control (0%) for mix ratio 1:1$^1/_2$:3.

More so, there was a decrease of concrete strength with percentage replacement of Groundnut Shell Ash and Marble Dust at 7 days for 20%, 14 days for 15%, 21 days for 20% and an initial increase of strength value and later dropped at 15% and 20% for 28 days. Hence, all the percentage replacement of cement with Groundnut Shell Ash and Marble Dust where less than control (0%) except at 14 days of 10% replacement for mix ratio 1:2:4. Since the minimum compressive strength of the concrete for both mix ratios is 13 N/mm² at 28days of curing which is in accordance with BS 5224 (1976) of 6 N/mm² after 28days for masonry cement, Groundnut Shell Ash – Marble Dust concrete can be used for concrete works where strength is of less importance such as floor screed, mass concrete and mortar.

5. CONCLUSIONS ANDRECOMMENDATIONS

From the results obtained from various tests carried out, the following conclusions can be arrived at:

» The mineral admixture of Groundnut Shell Ash (GSA) and Marble Dust are not suitable materials for use as a pozzolan and non-pozzolan, since it did not satisfied the requirement for such a material by having a combined ($SiO_2 + Al_2O_3 + Fe_2O_3$) of 25.4021% which is less than 70%. The Slump values of the concrete shows thatthe concrete becomes less workable as the percentage replacement with Groundnut Shell Ash and Marble Dust increases, meaning that there is need for increment in water cement ratio. The compressive strength increases with curing age of concrete for 5%, 10% and 20%, but it decreases for 0% and 15% at 14 days for mix ratio 1:2:4.

» Also, the compressive strength increases with age of curing at 0%, 10%, 15% and 20%, but it decreases for 5% at 14 days for mix ratio 1:1$^1/_2$:3. However, 10% replacement of Groundnut Shell Ash and Marble Dust with 17.34N/mm^2 strength value for mix ratio 1:2:4 and 20% replacement of Groundnut Shell Ash and Marble Dust with 18.37N/mm^2 strength value for mix ratio 1:1$^1/_2$:3 should be adopted when replacing this admixture with cement. Since the minimum compressive strength of the concrete for both mix ratios is 13N/mm^2 at 28days of curing which is in accordance with BS 5224 (1976) of 6 N/mm^2 after 28days for masonry cement, GSA – MD concrete can be used for concrete works where strength is of less importance such as floor screed, mass concrete and mortar.

Based on the results obtained from various test carried out, the following recommendations can be made:

1. General public should be sensitized on how Groundnut Shell Ash and Marble Dust could be used as a partial replacement of cement to achieve the profit desired without lowering the standard.
2. Concretes with the mineral admixture of Groundnut Shell Ash and Marble Dust should be allowed to cure for 50days or more, for completion of activities for pozzolanic and non-pozzolanic.
3. There is need for each mineral admixtures to be used separately to ascertain if Groundnut Shell Ash is a good pozzolan and Marble Dust a good non-pozzolan.
4. There should be an increase in water cement ratio as the percentage replacement increases for the concrete to be workable.
5. Further research work on replacement of cement with mineral admixtures of Groundnut Shell Ash and Marble Dust at percentage above 20% should be carried out for different curing ages.

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