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PHYSIO-CHEMICAL ASSESSMENT OF GROUNDNUT SHELL ASH (GSA) BLENDED CALCIUM CHLORIDE ($CACl_2$) AS SUPPLEMENTARY CEMENTING MATERIAL

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Abstract: This study examine the effect of groundnut shell ash (GSA) blended calcium chloride ($CaCl_2$) as supplementary cementing materials. The replacement levels of OPC with groundnut shell ash (GSA) were 0%, 5%, 10%, 15% and 20%. 1% of calcium chloride was blended with OPC/GSA in all experimental work. The following physical properties were determine on OPC and GSA; fineness test and specific gravity test while standard consistency and setting time test were conducted on OPC/GSA and OPC/GSA/$CaCl_2$. The chemical composition of OPC and GSA was also determined. The result of the standard consistency revealed that as the percentage replacement increases, the consistency also increases for both OPC/GSA and OPC/GSA/$CaCl_2$ respectively. However, the initial and final setting time shows that OPC/GSA/$CaCl_2$ set faster than OPC/GSA.
Keywords: Groundnut Shell (GS), Groundnut Shell Ash (GSA), Calcium Chloride ($CaCl_2$), Cement (OPC)

INTRODUCTION

Nigeria is a major producer of groundnut in the world with an average annual production of about one million tons. Groundnut production generates large amount of process residues such as groundnut shell (Ajobo, 2014). Groundnut shell is a by-product groundnut pod which is usually burnt, dumped or left to decay naturally. It constitutes about 25 % of the total pod (husk and seeds) mass.

Due to the growing environmental concern and the need to conserve energy and resources, efforts have been made to properly burn the shell to ash and to examine the ash with a view to utilizing it for useful purposes (Egbe – Ngun *et. al.,* 2014). In Lafia, the capital of Nasarawa State of Nigeria, the shell is abundantly available from October to May (Alu *et. al.,* 2012).

The shells can also be found in large quantity in Kwara state (Tsaragi, Lafiaji, Kaima and Pategi), Niger state (Bida) and many parts in Nigeria. Groundnut Shell Ash (GSA) is obtained by the combustion of groundnut shell.

MATERIALS AND METHODS

Materials

» Ordinary Portland cement (OPC) – Dangote cement brands 42.5R was used.
» Distilled water was used throughout this study.
» Calcium Chloride Anhydrous ($CaCl_2$, 95% Assay), which conformed to ASTM C494 (1999) were used.
» The groundnut shells (locally available materials) were collected from a milling store at Tsaragi, Edu Local Government of Kwara State. The groundnut shells were burnt to ashes at a temperature of 650^{0}C by Thermolyne Furnace at Foundry and Forging Workshop, Mechanical Engineering Department Federal Polytechnic Offa. The ashes were further grounded to a require level of finer particles with milling machine and allow to pass through sieve No.200 (75 µm). The groundnut shell, groundnut shell ash and grinded groundnut shell ash are shown in Figure 1. a, b and c respectively.

Methods

The experimental program was designed to examine the effect of groundnut shell ash (GSA) blended calcium chloride ($CaCl_2$) as supplementary cementing materials. The replacement levels of OPC with groundnut shell ash (GSA) were 0%, 5%, 10%, 15% and 20%. 1% of calcium chloride was blended with OPC/GSA in all experimental work.

The following physical properties were determine on OPC and GSA; Fineness test and Specific Gravity test while Standard Consistency and Setting Time test were conducted on OPC/GSA and OPC/GSA/$CaCl_2$. The chemical compositions of OPC and GSA were determined at SMO Laboratory, Joyce 'B' Road, off Mobil-Ring Road, Ibadan, Nigeria.

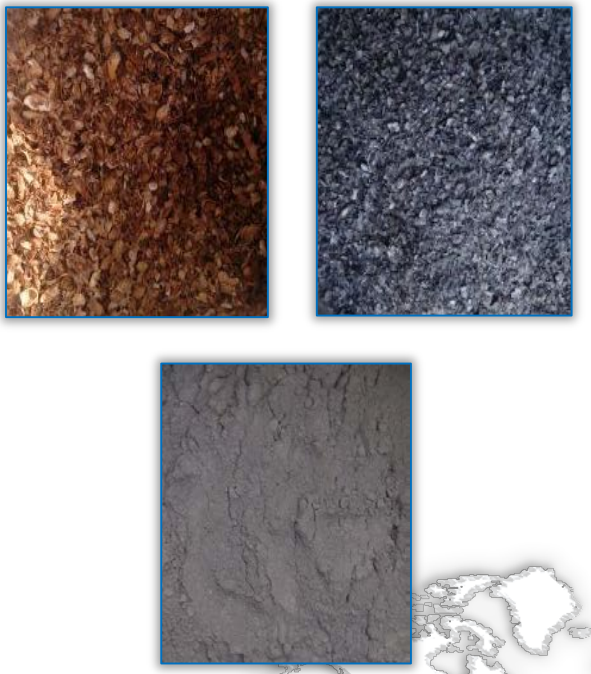

Figure 1: (a) Groundnut Shell, (b) Groundnut Shell Ash and (c) Grinded Groundnut Shell Ash

RESULTS AND DISCUSSION

Chemical (Oxides) Composition of OPC and GSA

The results of oxides composition of OPC and GSA tested are shown in Table 1.

Table 1: Oxides Composition of OPC and GSA

OXIDES (%)	OPC	GSA
SiO_2	19.63	19.69
Al_2O_3	5.84	0.95
Fe_2O_3	3.98	0.68
CaO	57.75	1.23
MgO	1.44	0.59
K_2O	0.16	1.67
Na_2O	0.27	1.77
SO_3	0.13	0.08
Loss on Ignition (LOI)	1.64	14.36

Comparison of Oxides Composition of OPC

The comparison of the OPC (Dangote Brand) tested with standard and other research work is shown in Table 2. From the comparison in Table 2, the values of SiO_2, Al_2O_3, Fe_2O_3, and MgO fell within the limit specified by SP:23 (1982) but the value of CaO is below the required limit. However, the value of SiO2, Al2O3, Fe2O3, CaO and MgO corresponds with that of Faleye et al., (2009).

Comparison of Oxides Composition of GSA

The comparison of the groundnut shell ash (GSA) tested with previous research work is shown in Table 3.

Table 2: Comparison of Oxides Composition of OPC

Oxides (%)	OPC (Tested)	SP 23 (1982) Indian Standard	Faleye, *et al.*, (2009) Dangote Brand
SiO_2	19.63	19 – 24	20.62
Al_2O_3	5.84	3 – 6	6.01
Fe_2O_3	3.98	1 – 4	3.22
CaO	57.75	59 – 64	59.6
MgO	1.44	0.5 – 4	3.65
K_2O	0.16	-	-
Na_2O	0.27	-	0.71
SO_3	0.13	-	2.46
LOI	1.64	-	-

Table 3: Comparison of Oxides Composition of GSA

OXIDES (%)	GSA (Tested)	Alabadan et. al. (2006)	Buhari et. al. (2013)
SiO_2	19.69	15.92	16.21
Al_2O_3	0.95	6.73	5.93
Fe_2O_3	0.68	1.93	1.80
CaO	1.23	8.66	8.69
MgO	0.59	6.12	6.74
K_2O	1.67	-	15.73
Na_2O	1.77	-	9.02
SO_3	0.08	-	6.21
LOI	14.36	-	4.80

ASTM C-618 (2005) specifies that the sum of SiO_2, Al_2O_3, and Fe_2O_3 of a pozzolanic material should not be less than 70%. The sum of SiO_2, Al_2O_3, and Fe_2O_3 of the groundnut shell ash (GSA) tested is 21.32% which is low to that of Alabadan et. al. (2006), Buhari et. al. (2013) and 70% specified by ASTM C-618 (2005). However, the result of the groundnut shell ash (GSA) tested shows that silicon dioxide (SiO_2) have the highest percentage of oxide composition.

The result also shows that the chemical composition of the groundnut shell ash compared varies from each other.

Fineness of OPC and GSA

The fineness of the cement was conducted by sieve method using sieve size 90microns. The results of the fineness test are shown in Table 4.

Table 4: Fineness of OPC and GSA

S/No.	Test Samples	Fineness (%)
1.	OPC	2.5
2.	GSA	3.0

The results of the fineness test shows that both OPC and GSA are less than 10% of the total weight of sample (100g) used for conducting the test.

Specific Gravity of OPC and GSA

The results of specific gravity of the selected brands of cement are shown in Table 5.

Table 5: Specific gravity of OPC and GSA

S/No.	Test Samples	Specific Gravity
1.	OPC	3.13
2.	RHA	1.74

Typical values for specific gravity of Portland cement as specified by Chen et. al. (2003) lie within the range of 3.1 to 3.2. The results of specific gravity of the cement tested as shown in Table 5 fells within the acceptable limits.

The result of the specific gravity of GSA is low to that of OPC but the value is higher than the one reported by Raheem et. al., 2013 (1.54) and Buhari et. al., 2013 (1.54)

Standard Consistency of OPC/GSA and OPC/GSA/$CaCl_2$

The Standard Consistency test conformed with IS 4031-4 (1988).

Table 6: Standard Consistency of OPC/GSA and OPC/GSA/$CaCl_2$

S/No.	Replacement of OPC with GSA (%)	Consistency (%)
1	0%	27
2	5% GSA	30
	5 GSA%, 1% $CaCl_2$	29
3	10% GSA	33
	10 GSA%, 1% $CaCl_2$	32.5
4	15% GSA	36
	15 GSA%, 1% $CaCl_2$	35
5	20% GSA	36.5
	20 GSA%, 1% $CaCl_2$	35.5

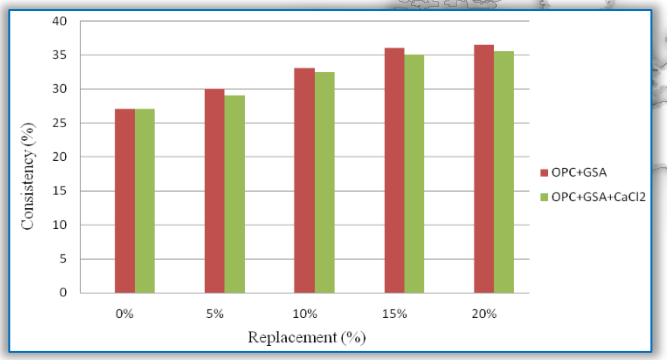

Figure 2: Bar Chart of Consistency against GSA-Replacement

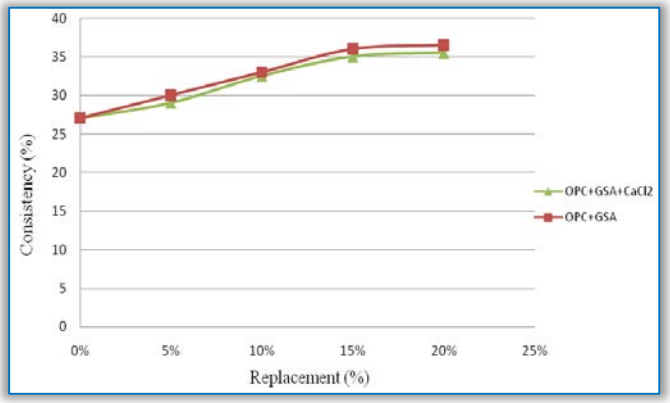

Figure 3: Graph of Consistency against GSA-Replacement

The results from Table 6 above shows that 20% groundnut shell ash (GSA) replacement have the highest consistency (amount of water required to give a paste) while 0% have the lowest consistency.

However, as the percentage replacement increases, the consistency also increases for both OPC/GSA and OPC/GSA/$CaCl_2$. The results are represented in Figure 2 and 3 respectively.

Setting Time of OPC/RHA and OPC/RHA/$CaCl_2$

The Setting Time test conformed with IS 4031-5 (1988).

Table 7: Setting Time of OPC/GSA and OPC/GSA/$CaCl_2$

S/No.	Replacement of OPC with GSA (%)	Setting time (Mins.) Initial	Final
1	0%	81	141
2	5% GSA	110	200
	5 GSA%, 1% $CaCl_2$	95	185
3	10% GSA	125	215
	10 GSA%, 1% $CaCl_2$	110	185
4	15% GSA	95	200
	15 GSA%, 1% $CaCl_2$	80	170
5	20% GSA	80	170
	20 GSA%, 1% $CaCl_2$	65	155

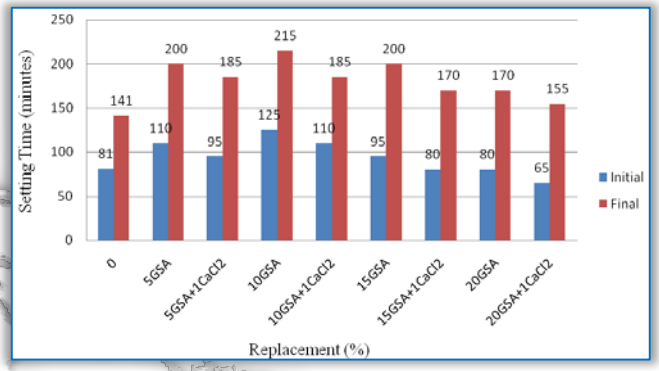

Figure 4: Bar Chart of Setting Time against GSA-Replacement

American Standard ASTM C 150-07 prescribes a minimum time for the initial set of 45 minutes and final set of 375 minutes while IS 269 (2013) and IS 12269 (2013) prescribes a minimum time for the initial set of 30 minutes and maximum final set of 600 minutes.

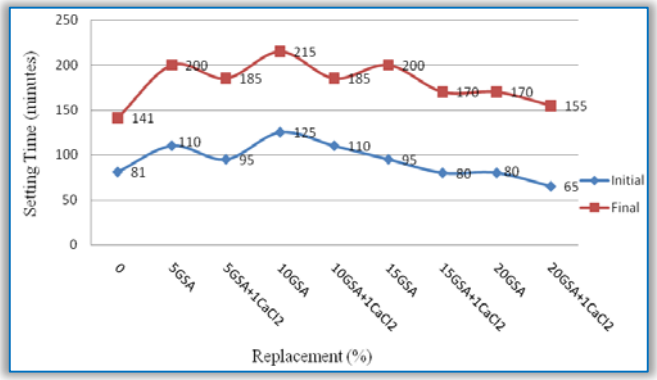

Figure 5: Graph of Setting Time against GSA-Replacement

The result of the setting time shows that all percentage replacement (OPC/GSA and OPC/GSA/$CaCl_2$) conformed to the minimum initial time and maximum final time specified by ASTM C 150-07, IS 269 (2013) and IS 12269

(2013). However, the initial and final setting time shows that OPC/GSA/$CaCl_2$ set faster than OPC/GSA. The results are further represented in Figure 4 and 5 respectively.

CONCLUSIONS

From the investigation and analysis of results, the following conclusions can be drawn from this present study:

- The value of calcium oxide (CaO) of cement is below the required limit. However, the value of SiO2, Al2O3, Fe2O3, CaO and MgO corresponds with that of Faleye *et al.,* (2009).
- The chemical composition of the groundnut shell ash (GSA) shows that silicon dioxide (SiO_2) have the highest percentage of oxide composition. However, the chemical composition of the groundnut shell ash (GSA) compared varies from each other.
- The specific gravity of cement (OPC) falls within the acceptable limits. However, the result of the specific gravity of GSA is low to that of OPC but the value is higher than the one reported by Raheem *et. al.,* 2013 (1.54) and Buhari *et. al.*, 2013 (1.54).
- The standard consistency shows that 20% groundnut shell ash (GSA) replacement have the highest consistency (amount of water required to give a paste) while 0% have the lowest consistency. However, as the percentage replacement increases, the consistency also increases for both OPC/GSA and OPC/GSA/$CaCl_2$.
- The setting time shows that all percentage replacement (OPC/GSA and OPC/GSA/$CaCl_2$) conformed to the minimum initial time and maximum final time specified by ASTM C 150-07, IS 269 (2013) and IS 12269 (2013). However, the initial and final setting time shows that OPC/GSA/$CaCl_2$ set faster than OPC/GSA.

References

[1.] Ajobo, J.A.: Densification Characteristics of Groundnut Shell. International Journal of Mechanical and Industrial Technology, Vol. 2, Issue 1, 150-154, (2014).

[2.] Alu, S.E; Adua, M.M; Damulak, H.I; Umar, R.S; Abubakar, A.D; and Matthew, U.D.: Growth rate and nutrient digestibility by broiler birds fed alkali-treated groundnut (Arachis hypogea) shell meal-based diets, Scholarly Journal of Agricultural Science Vol. 2(10), 231-237, (2012).

[3.] ASTM C494-99: Standard Specification for Chemical Admixtures for Concrete, American Society for Testing and Materials (ASTM International), 100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA 19428-2959, United States, (1999).

[4.] ASTM C 618-05: Specifications for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete, American Society for Testing and Materials (ASTM International), 100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA 19428-2959, United States, (2005).

[5.] ASTM C 150-07: Standard Specification for Portland Cement, American Society for Testing and Materials (ASTM International), 100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA 19428-2959, United States, 467-471, (2007).

[6.] Chen, W.F. and Richard, J.Y: The Civil Engineering Handbook, 2nd Edition, (Chp. 40, Section 40.2), 2000 N.W. Corporate Blvd., Boca Raton, Florida 33431, CRC Press LLC, (2003).

[7.] Egbe – Ngu, N.O. and Okorie A.U.: Effect of Particle Size of Groundnut Husk Ash (GHA) in Cement Paste and Mortar, International Journal on Recent and Innovation Trends in Computing and Communication, Volume 2, Issue 9, 2764-2769, (2014).

[8.] Faleye, F. J., Ogunnubi, S. and Olaofe, O.: Chemical and Physical Analyses of Selected Cement Samples in Nigerian Market, Bangladesh Journal of scientific And Industrial research, 44(1), 41-50, (2009).

[9.] IS 269: Indian Standard Specification for Ordinary Portland Cement, 33 Grade, Bureau of Indian Standards, New Delhi 110002, 5th Revision, pp.1-5, March 2013.

[10.] IS 4031-4: Indian Standard Methods of Physical Tests for Hydraulic Cement, Part 4, Determination of Consistency of Standard Cement Paste, Bureau of Indian Standards, New Delhi 110002, pp.1-2, (1988), 1st Revision, 3rd Reprint October, 1997.

[11.] IS 4031-5: Indian Standard Methods of physical tests for hydraulic cement, Part 5, Determination of initial and final setting times, Bureau of Indian Standards, New Delhi 110002, pp.1-2, 1st Revision, 1988, (Reaffirmed 2000).

[12.] IS 12269: Indian Standard Specification for Ordinary Portland Cement, 53 Grade": Bureau of Indian Standards, New Delhi 110002, pp.1-6, 1st Revision, March 2013.

[13.] SP 23: Handbook on Concrete Mixes": Based On Indian Standards. Bureau of Indian Standards, New Delhi 110002, (1982) 6th Reprint, November 2001.

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