[1.]M.A. ANIFOWOSE, [2.]J.A. IGE, [3.]A.L YUSUF, [4.]S.A. ADEBARA, [1.]A.A. ABDULKARIM

PHYSIO-CHEMICAL ASSESSMENT OF RICE HUSK ASH (RHA) BLENDED CALCIUM CHLORIDE ($CaCl_2$) AS SUPPLEMENTARY CEMENTING MATERIALS

[1.]Department of Civil Engineering, Federal Polytechnic Offa, P.M.B 420, Offa, Kwara State, NIGERIA
[2.]Department of Civil Engineering, Ladoke Akintola University of Technology, Ogbomoso, NIGERIA
[3.]Post Graduate Student, Ladoke Akintola University of Technology, Ogbomoso, NIGERIA
[4.]Department of Civil Engineering, Federal Polytechnic, Ede, NIGERIA

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

1. INTRODUCTION

Rice husk is one of the most widely available agricultural wastes in many rice producing countries around the world. Globally, approximately 600 million tons of rice paddies are produced each year. On average 20% of the rice paddy is husk, giving an annual total production of 120 million tonnes (Kumar *et al.,* 2012). In Nigeria 748,000 - 990,000 tons of rice husk was projected to have been produced in 2010 based on estimated paddy rice production figure of 3.4 - 4.5 million tonnes (Abalaka, 2012). Rice husk is abundantly produced in many parts of Nigeria such as Abakaliki, Afikpo, Ogoja, Ikepe, Lafiagi, Badeji, Pategi, Sokoto, Birnin-Kebi, Abeokuta, Benin and Delta region (Opara, 2011). In majority of rice producing countries much of the husk produced from processing of rice is either burnt or dumped as waste (Kumar *et al.,* 2012). The combustion of rice husk leads to rice husk ash (RHA).

The use of RHA in cement or concrete as a supplementary cementing material has been increased recently. Supplementary use of RHA in cement or concrete is not a new technique but it was started since early 1970. Since then Many Research and development in various parts of the world, have shown that rice husk ash (RHA) can be used as a partial replacement for cement in concrete (Khassaf *et al.,* 2014).

2. MATERIALS AND METHODS

— Materials

- **Cement:** Ordinary Portland cement (OPC) – Dangote cement brands 42.5R was used.
- **Distilled Water:** Distilled water was used throughout this research.
- **Calcium Chloride:** Calcium Chloride Anhydrous ($CaCl_2$, 95% Assay), which conformed to ASTM C494 (1999) were used.

Figure 1: (a) Rice Husk, (b) Rice Husk Ash and (c) Grinded Rice Husk Ash

- **Rice Husk Ash (RHA):** The Risk husks (locally available materials) were collected from a rice milling store at Ijagbo, Oyun Local Government of Kwara State. The rice husks 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 Rice Husk, Rice Husk Ash and Grinded Rice Husk Ash are shown in Figure 1a, b and c respectively.

— Methods

The experimental program was designed to examine the effect of rice husk ash (RHA) blended calcium chloride ($CaCl_2$) as supplementary cementing materials. The replacement levels of OPC with rice husk ash (RHA) were 0%, 5%, 10%, 15% and 20%. 1% of calcium chloride was blended with OPC/RHA in all experimental work. The following physical properties were determine on OPC and RHA; Fineness test and Specific Gravity test while Standard Consistency and Setting Time test were conducted on OPC/RHA and OPC/RHA/$CaCl_2$. The chemical compositions of OPC and RHA were determined at SMO Laboratory, Joyce 'B' Road, off Mobil-Ring Road, Ibadan, Nigeria.

Table 1: Oxides Composition of OPC and RHA

OXIDES (%)	OPC	RHA
SiO_2	19.63	46.33
Al_2O_3	5.84	1.13
Fe_2O_3	3.98	0.31
CaO	57.75	0.08
MgO	1.44	0.74
K_2O	0.16	0.73
Na_2O	0.27	0.84
SO_3	0.13	0.19
Loss on Ignition (LOI)	1.64	4.96

3. RESULTS AND DISCUSSION

— Chemical (Oxides) Composition of OPC and RHA

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

— 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) and Neville, A.M. (2011) but the value of CaO is below the required limit. However, the value of SiO_2, Al_2O_3, Fe_2O_3, CaO and MgO corresponds with that of Faleye *et al.,* (2009).

Table 2: Comparison of Oxides Composition of OPC

OXIDES (%)	OPC (Tested)	SP 23 (1982) Indian Standard	Neville, A.M. (2011)	Faleye, *et al.,* (2009) - Dangote Brand
SiO_2	19.63	19 – 24	17 – 25	20.62
Al_2O_3	5.84	3 – 6	3 – 8	6.01
Fe_2O_3	3.98	1 – 4	0.5 – 6.0	3.22
CaO	57.75	59 – 64	60 – 67	59.6
MgO	1.44	0.5 – 4	0.5 – 4.0	3.65
K_2O	0.16	-	-	-
Na_2O	0.27	-	0.3 – 1.2	0.71
SO_3	0.13	-	2.0 – 3.5	2.46
LOI	1.64	-	-	-

— Comparison of Oxides Composition of RHA

The comparison of the rice husk ash (RHA) tested with previous research work is shown in Table 3. 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 rice husk ash (RHA) tested is 47.77% which is low to that of Ephraim et al. (2012), Akhionbare (2013) and 70% specified by ASTM C-618 (2005). However, the result of the rice husk ash (RHA) tested shows that silicon dioxide (SiO_2) have the highest percentage of oxide composition. The result also shows that the chemical composition of the rice husk ash compared varies from each other. Olawale *et al.,* (2012) reported that the chemical composition of the rice husk ash varies from Rice husk to Rice husk which may be due to geographical and climatic conditions, type of rice and the quantity of fertilizer used.

Table 3: Comparison of Oxides Composition of RHA

OXIDES (%)	RHA (Tested)	Ephraim *et. al.* (2012)	Akhionbare (2013)
SiO_2	46.33	88.32	67.30
Al_2O_3	1.13	0.46	4.90
Fe_2O_3	0.31	0.67	0.95
CaO	0.08	0.6	1.36
MgO	0.74	0.44	-
K_2O	0.73	2.91	-
Na_2O	0.84	-	-
SO_3	0.19	-	2.80
LOI	4.96	5.81	17.78

— Fineness of OPC and RHA

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

Table 4: Fineness of OPC and RHA

S/No.	Test Samples	Fineness (%)
1.	OPC	2.5
2.	RHA	4

Table 5: Specific gravity of OPC and RHA

S/No.	Test Samples	Specific Gravity
1.	OPC	3.12
2.	RHA	1.95

— Specific Gravity of OPC and RHA

The results of specific gravity of the selected brands of cement are shown in Table 5. 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 RHA is low to that of OPC but the value is higher than the one reported by Akeke *et. al.,* 2013 (1.55) and Ettu *et. al.*, 2013 (1.80).

— Standard Consistency of OPC/RHA and OPC/RHA/$CaCl_2$

The Standard Consistency test conformed with IS 4031-4 (1988) and the result is presented in Table 6.The results from Table 6 above shows that 20% rice husk ash (RHA) 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/RHA and OPC/RHA/$CaCl_2$. The results are represented in Figure 2 and 3 respectively.

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

The Setting Time is presented in Table 7 and the test conformed with IS 4031-5 (1988).

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

S/No.	Replacement of OPC with RHA (%)	Setting time (Mins.) Initial	Final
1	0%	81	141
2	5% RHA	95	185
	5 RHA%, 1% $CaCl_2$	80	155
3	10% RHA	95	200
	10 RHA%, 1% $CaCl_2$	80	170
4	15% RHA	50	170
	15 RHA%, 1% $CaCl_2$	50	155
5	20% RHA	65	185
	20 RHA%, 1% $CaCl_2$	50	170

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. The result of the setting time shows that all percentage replacement (OPC/RHA and OPC/RHA/$CaCl_2$) conformed to the minimum initial setting time and maximum final setting time specified by ASTM C 150-07, IS 269 (2013) and IS 12269 (2013). However, the initial and final setting time shows that OPC/RHA/$CaCl_2$ set faster than OPC/RHA. The results are further represented in figure 4 and 5 respectively.

4. CONCLUSIONS

From the investigation and analysis of results, the following conclusions can be drawn:

— The value of calcium oxide (CaO) of cement is below the required limit. However, the values of SiO_2, Al_2O_3, Fe_2O_3, CaO and MgO corresponds with that of Faleye *et al.*, (2009).

— The chemical composition of the rice husk ash (RHA) shows that silicon dioxide (SiO_2) have the highest percentage of oxide composition. However, the chemical composition of the rice husk ash compared varies from each other.

— The specific gravity of cement (OPC) falls within the acceptable limits. However, the result of the specific

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

S/No.	Replacement of OPC with RHA (%)	Consistency (%)
1	0%	27
2	5% RHA	29.5
	5 RHA%, 1% $CaCl_2$	29
3	10% RHA	32.5
	10 RHA%, 1% $CaCl_2$	32
4	15% RHA	35.7
	15 RHA%, 1% $CaCl_2$	34
5	20% RHA	35.8
	20 RHA%, 1% $CaCl_2$	34.5

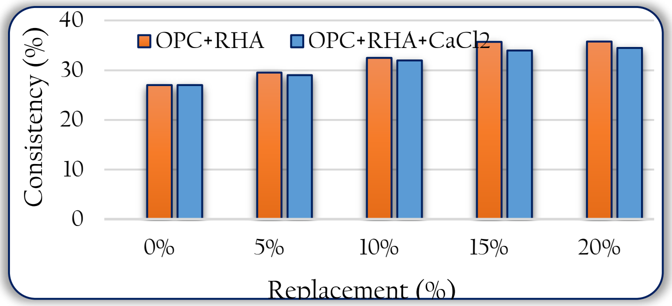

Figure 2: Bar Chart of Consistency against RHA-Replacement

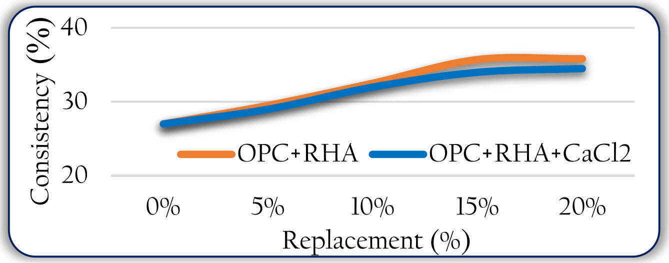

Figure 3: Graph of Consistency against RHA-Replacement

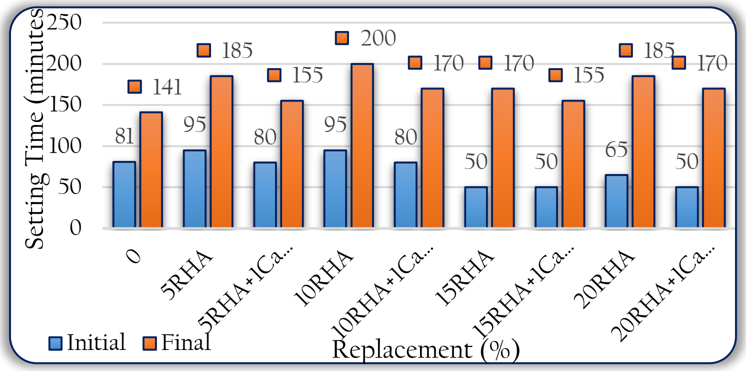

Figure 4: Bar Chart of Setting Time against RHA-Replacement

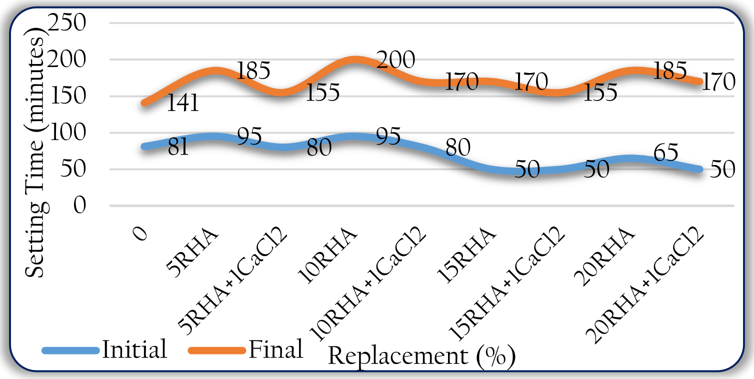

Figure 5: Graph of Setting Time against RHA-Replacement

gravity of RHA is low to that of OPC but the value is higher than the one reported by Akeke *et. al.,* 2013 (1.55) and Ettu *et. al.*, 2013 (1.80).

- The standard consistency shows that 20% rice husk ash (RHA) 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/RHA and OPC/RHA/$CaCl_2$.
- The setting time shows that all percentage replacement (OPC/RHA and OPC/RHA/$CaCl_2$) 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/RHA/$CaCl_2$ set faster than OPC/RHA.

References

[1] Abalaka, A.E.: Effects of Method of Incineration on Rice Husk Ash Blended Concrete, ATBU Journal of Environmental Technology, 5(1), 34 – 47, (2012).
[2] Akeke, G.A.; Ephraim, M.E.; Akobo, I.Z.S and Ukpata, J.O.: Structural Properties of Rice Husk Ash Concrete, International Journal of Engineering and Applied Sciences, 3(3), 57-62, (2013).
[3] Akhionbare, W.N.: A Comparative Evaluation of the Application of Agrowaste as Construction Material, International Journal of Science and Nature, 4(1),141-144, (2013).
[4] 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).
[5] 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).
[6] 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).
[7] 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).
[8] Ephraim, M.E.; Akeke, G.A. and Ukpata, J.O.: Compressive Strength of Concrete with Rice Husk Ash as Partial Replacement of Ordinary Portland cement, Scholarly Journal of Engineering Research, 1(2), 32-36, (2012).
[9] Ettu, L.O.; Osadebe, N.N. and Mbajiorgu, M.S.W.: Suitability of Nigerian Agricultural By - Products as Cement Replacement for Concrete Making, International Journal of Modern Engineering Research (IJMER), 3(2),1180 – 1185, (2013).
[10] 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).
[11] 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.
[12] 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.
[13] 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).
[14] 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.
[15] Khassaf, S. I.; Jasim, A. T. and Mahdi, F.K.: Investigation the Properties of Concrete Containing Rice Husk Ash to Reduction the Seepage in Canals, International Journal of Scientific & Technology Research, 3(4), 348-354, (2014).
[16] Kumar, A.; Mohanta, K.; Kumar, D. and Parkash, O.: Properties and Industrial Applications of Rice husk: A review, International Journal of Emerging Technology and Advanced Engineering, 2(10), 86-90, (2012).
[17] Neville, A.M.: Properties of concrete, 5th Edition, Edinburgh Gate, Harlow, Essex CM20 2JE, England, Pearson Education Limited, (2011).
[18] Olawale, O. and Oyawale, F.A.: Characterization of Rice Husk via Atomic Absorption Spectrophotometer for Optimal Silica Production, International Journal of Science and Technology, 2(4), 210-213, (2012).
[19] Opara, P.N.: Low Cost Materials for Building and Construction: A Case Study of Rice Husk. Journal of Sustainable Development and Environmental Protection, 1(1): 87-93, (2011).
[20] SP 23: Handbook on Concrete Mixes": Based On Indian Standards. Bureau of Indian Standards, New Delhi 110002, (1982) 6th Reprint, November 2001.

ISSN 1584 - 2665 (printed version); ISSN 2601 - 2332 (online); ISSN-L 1584 - 2665