Investigating the Upgrading of Non-Pozzolans with Pozzolanic Materials

Ololade O. Adegbesan[1] Olufunke A. Ayegbusi [2] & Omisande L.A[3].
[123] Department of Civil Engineering
The Federal Polytechnic
Ilaro, Ogun State Nigeria
E-mail: Ololade.adegbesan@federalpolyilaro.edu.ng
Phone: +2348062306055

ABSTRACT

The increase in demand for safe, durable and economical concrete structure due to the exorbitant cost of manufacturing cement; the environmental effects of the release of toxic gases from cement production into the atmosphere that poses threats to human and to the environment in diverse ways necessitated researching into how agricultural wastes can be harnessed to help reduce to a minimal level, the cost of good concrete production when pozzolanic materials are used to partially substitute cement. Maize cob ash (MCA), guava leaf ash (GLA), cocoa pod ash (CCPA) and almond pod ash (APA) were weighed, mixed and calcined at their optimum calcining temperatures of 800^0C, 600^0C, 800^0C, 700^0C. The physical characteristics and chemical composition of the samples were determined through chemical analysis and X-ray fluorescence (XRF). The results showed that the total percentage of silicon dioxide, aluminium oxide and ferric oxide of maize cob ash (MCA) among the rest satisfied the ASTM requirements of 70%, while the physical mixture of maize cob ash (MCA) and guava leaves ash (GLA) only satisfied the ASTM requirement of 50% of Class C. The moisture content and loss on ignition for MCA met the stipulated standards out of all the samples The results obtained from X-ray fluorescence differs from the results obtained from chemical analysis, only MCA satisfies the requirements stipulated by ASTM C618, while the remaining samples does not meet the requirements. pozzolanic materials such as rice husk ash or oyster shell ash that has high percentage of silica, aluminium and iron can be physically mixed with a low or non- pozzolanic material to augment or complement non-pozzolanic material thus indicating that agro-wastes can be used without them constituting nuisance to the environment

Keywords: Almond pod ash, Cement, Cocoa pod ash, Guava leaf ash, Maize cob ash, Pozzolanic, Non-pozzolanic

iSTEAMS Proceedings Reference Format
Ololade O. Adegbesan, Olufunke A. Ayegbusi & Omisande L.A. (2019): Investigating The Upgrading of Non-Pozzolans with Pozzolanic Materials. Proceedings of the 16th iSTEAMS Multidisciplinary Research Nexus Conference, The Federal Polytechnic, Ilaro, Ogun State, Nigeria, 9th – 11th June, 2019. Pp 243-248. www.isteams.net - DOI Affix - https://doi.org/ 10.22624/AIMS/iSTEAMS-2019/V16N2P29

1. BACKGROUND TO THE STUDY

Cement & concrete production and usage is an essential part of civil engineering works, as good and intensively used as it is, its production causes increase in CO_2 emission leading to a rise in temperature of the atmospheres (Global warming). According to Akinboboye, Ogunfayo, and Dawodu (2012) and Cline et al, (2000), its cummulative and hazardous effects over timescales can be checkmated by using environmentally friendly materials such as pozzolan (artificial and agro-waste). Industrial and agricultural waste products such as PFA, SF, GGBS, RHA, CCPA and CCA unnecessarily occupy space when stored or create environmental hazards when dumped in landfill. Their utilization in the construction industry reduces the overall cost of construction, mitigates on the technical and environmental nuisance reduces solid waste, cuts on greenhouse gas emissions and conserves existing natural resources, thereby enhancing sustainability as well as improving the properties of fresh and hardened concrete Malhotra V. and Mehta P (1996). Malhotra V. and Mehta P. (1996) defined a pozzolan as a siliceous aluminous material which in itself possesses little or no cementitious property, but which will, in finely divided form in the presence of moisture, react chemically with calcium hydroxide (CH) at ordinary temperature to form compounds possessing cementitious properties Pozzolan are divided into two groups; Natural pozzolan and artificial pozzolan.

Artifical pozzolan can be obtained from agric wastes or by-product from high temperature process such as fly ash from coal-fired electricity generation. Other are silica fume, blast furnace slag, matekaoline, and some agro-based wastes such as rice husk ash. (M.S. Shetty, 2004). The reaction of pozzolans with calcium hydroxide (CH) under moist conditions is called pozzolanic reaction. The pozzolanic reaction occurs between calcium hydroxide, also known as portlandite ($Ca(OH)_2$), and silicic acid (H_4SiO_4 or as $Si(OH)_4$)

This research was to ascertain whether materials with high pozzolanic potentials such as maize cobs ash (MCA) and guava leaves ash (GLA) when physically mixed can be used to upgrade non-pozolanic materials such as cocoa pod ash (CCPA) and almond pod ash (APA). The significance of this research majorly is to help to reduce to a minimal level, the cost of good concrete production when pozzolanic materials are used to partially substitute cement. When this is done, the cost of concrete production will be significantly reduced. This as an aside, the usage of agro-waste as a pozzolan leaves the environment cleaner.

1.1 Statement of Problem

The increase in demand for safe, durable and economical concrete structure due to the exorbitant cost of manufacturing cement; the environmental effects of the release of toxic gases from cement production into the atmosphere that poses threats to human and to the environment in diverse ways necessitated researching into how agricultural wastes can be harnessed to help reduce to a minimal level, the cost of good concrete production when pozzolanic materials are used to partially substitute cement.

1.2. Objective

The main objective of this study is to ascertain whether the resulting mix of non-pozzolanic and pozzolanic materials can have pozzolanic properties.

2. METHODOLOGY

Maize cob ash (MCA), guava leaf ash (GLA), cocoa pod ash (CCPA) and almond pod ash (APA) were weighed and then mixed together physically. The resulting mixes were then calcined at their optimum calcining temperatures of 800^{0}C, 600^{0}C, 800^{0}C, 700^{0}C. The physical characteristics and chemical composition of the samples were determined through chemical analysis and X-ray fluorescence (XRF) on the following .

i. Silicon-dioxide (SiO2)
ii. Aluminium oxide (Al2O3)
iii. Iron oxide (Fe2O3)
iv. Calcium oxide (CaO)
v. Magnesium oxide (MgO)
vi. Moisture content
vii. Loss on ignition

That are present in the mixes and these then compared with the values stipulated for them in accordance with ASTM C618

3. DATA PRESENTATION

(a) CHEMICAL ANALYSIS

Table 1: ASTM-C618 specification for chemical composition of pozzolans in comparison with that of the samples.

Oxide composition, %	ASTM-C618 Specification	Samples						
		MCA	GLA	MCA+GLA	MCA+CCPA	MCA+APA	GLA+CCPA	GLA+APA
SiO2	SiO2 + Al2O3+ Fe2O3, min%=70.0	67.67	41.43	44.78	13.94	21.79	16.56	13.24
Al2O3		5.67	4.92	4.14	1.19	2.59	3.55	3.95
Fe2O3		2.45	1.85	4.96	1.19	4.18	4.60	4.30
CaO	_	5.79	17.94	9.66	5.10	15.87	7.72	13.24
MgO	_	2.57	7.43	3.27	4.26	4.46	7.83	0.69
LOI	Max % = 10.0	18.0	7.05					
MC	Max % =3.0	12.1	39.3					

(b) X-RAY FLUORESCENCE (XRF)

Table 2: ASTM-C618 Specification for Chemical Composition of Pozzolans in Comparison with the Samples

Oxide composition, %	ASTM-C618 Specification	Samples						
		MCA	GLA	MCA+GLA	MCA+CCPA	MCA+APA	GLA+CCPA	GLA+APA
SiO2 Al2O3 Fe2O3	SiO2 + Al2O3+ Fe2O3, min%=70.0	58.23 +11.04 +2.40 =71.67%	9.07 +4.62 +2.15= 15.84%	22.2 + 11.13 + 2.99 = 36.49%	10.73 + 3.19 + 0.49 = 14.41%	11.13 +7.83 + 5.23 = 24.19%	10.83 + 5.65 + 2.92 = 19.4%	11.06 + 8.30 + 3.01 = 22.37%
CaO		7.32	11.38	8.85	5.76	6.68	10.32	11.38
MgO		1.97	2.77	2.76	3.01	2.31	3.50	2.77
MC	Max % = 3.0	12.1	39.3					

Table 3: Major Compound composition of the samples with that of cement Control.

Chemical Compound,%	Samples							
	MCA	GLA	MCA+GLA	MCA+CCPA	MCA+APA	GLA+CCPA	GLA+APA	Cement OPC
C_3S	-525.93	-275.01	-328.93	-116.73	-118.47	-118.33	-74.53	55.5
C_2S	590.80	326.27	376.55	128.04	151.86	136.75	94.64	19.7
C_3A	411.78	220.50	259.11	100.49	96.24	98.67	66.69	6.6
C_4AF	7.45	5.62	15.10	3.62	12.72	13.99	13.08	9.3
Total %	484.1	277.38	321.83	14.93	142.35	131.08	99.88	91.1

4. DISCUSSION OF FINDINGS

It is obvious from the table 1 presented above that total percentage of silicon dioxide, aluminium oxide and ferric oxide (i.e. SiO2 + Al2O3 + Fe2O3) of maize cob ash (MCA) only satisfies ASTM requirements of 70%, and the physical mixture of maize cob ash (MCA) and guava leaves ash (GLA) only satisfies the ASTM requirement of 50% as Class C, also moisture content and loss on ignition for MCA met the stipulated standards while the samples of MCA+GLA, MCA+CCPA, MCA+APA, GLA+CCPA and GLA+APA all fall short of specifications.

The results obtained from X-ray fluorescence differs from the results obtained from chemical analysis, only MCA satisfies the requirements stipulated by ASTM C618, while the remaining samples does not meet the requirements. The values in table 3 shows that tricalcium silicate (C_3S) of all the samples has a negative value, and this confirmed that all the samples all has high C_3S deficiency. C_3A and C_4AF possess value that are high than the control concrete which the total oxide composition of the sample is higher than that of the control cement

5. CONCLUDING REMARKS

The following conclusions were drawn from the research after the samples has beeen subjected to various laboratory tests using chemical and X-ray fluorescence analytical methods, that:

I. The total percentage composition of SiO_2, Al_2O_3, and Fe_2O_3 in MCA using chemical analysis method and X-ray fluorescence only add up to the minimum of 70% specified for pozzolans by ASTM-C618, hence MCA is pozzolanic. While the physical mixture of MCA and GLA only add up to 50% as specified for class C using chemical analysis method only.
II. The total percentage composition of SiO_2, Al_2O_3, and Fe_2O_3 in MCA and MCA+GLA for chemical analysis method was 75.79%, 53.88% and 71.67% for X-ray fluorescence. While the physical mixture of MCA+CCPA, MCA+APA, GLA+CCPA and GLA+APA all fall short the standard stipulated by ASTM-C618.
III. The moisture content values of 12.1, 39.3, 39.9, 68.9% loss on ignition values of 18.0, 28.0, 21.0% for MCA, GLA, CCPA and APA exceeded the prescribed 3% and 10% respectively as stipulated by ASTM-C618, except for GLA which the value of loss on ignition fall short of standard.
IV. The use of Bogue's equation shows that the samples has a high deficiency of tricalcium silicate (C_3S) due to negative values obtained, while it has a very high dicalcium silicate (C_2S), and tricalcium aluminate (C_3A) to that of cement control.

6. CONTRIBUTIONS TO KNOWLEDGE

In view of the fact that the physical mixture of pozzolanic and non-pozzolanic material of maize cob ash and guava leave ash has add up to 50% which is classify as class C as laid down by ASTM-C618, it is now an eyeopener that pozzolanic materials such as rice husk ash or oyster shell ash that has high percentage of silica, aluminium and iron can be physically mixed with a low or non- pozzolanic material to augment or complement non-pozzolanic material thus indicating that agro-wastes can be used without them constituting nuisance to the environment.

REFERENCES

1. Akinboboye F, Ogunfayo I, and Dawodu H. (2012) Assessment of the severity of CO2 emmission from anthill soils used as replacement for shale in cement manufacture. International Journal of Academic Research in Business and Social Sciences, Vol 2, No 12,2012
2. American Society for Testing and Materials (ASTM) (1997). Standard Specification for Coal Fly Ash and raw calcined natural possolan for use as a mineral admixture in concrete. ASTM C 618-97.
3. Cline, J.A., Bijl, M., and Torrenueva, A. (2000). Coal fly ash as a soil conditioner for field crops in southern Ontario. J. Environ. Qual, 29, 1982.
4. Malhotra V. and Mehta P (1996) Pozzolanic and cementitious materials In: Advances in concrete technology, Vol. 1. Amsterdam: Gordon and Breach 1996
5. NSW Environment Protection Agency (2006). Protection of the Environment Operations (Waste) Regulation 2005—General Exemption Under Part 6. The fly ash and bottom ash from burning NSW or Queensland coal exemption 2006
6. Shetty,M.S. 2004 Concrete Technology. New Delhi: S. Chand and Company