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ARTICLE

Characteristics of Ordinary Portland Cement Paste Containing Rice Husk Ash and Conplast [SP 430]

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ABSTRACT

An experimental investigation on rice husk ash (RHA) and Conplast SP 430 (CP-admixture) was carried out to evaluate their effects on the paste characteristics (soundness, consistency, initial and final setting times). The cement content used was 300g and the brand was 'Ashaka' Portland cement conforming to BS EN 12 1973. Various combinations of the mixtures OPC-RHA-CP-admixture were used to establish performance characteristics of the pastes. Statistical characteristics, and linear regression models (no-transformation, λ = 0.5, and Box-Cox transformation) were developed on the experimental data for decisions on their performances.

1. Introduction

Nigeria produces approximately 4.3 million tons of rice paddy per year. The waste which is the husk has an approximate volume of 1.1 to 2 million tons per year [1,2]. These wastes can translate to tremendous wealth if properly and economically utilized mostly in our construction industry. In cement technology, this material is classified as a supplementary cementing material (SCM) or cement replacement material (CRM), as the case may be. It is also characterized as a low grade material. One of the setbacks in the use of these low grade materials is the lack of appropriate technology in processing, and the proper knowledge of its behavior when used as a composite. In this research the focus is on rice husk ash. The technology in the use of SCMs/CRMs is still at the teething stage in Africa and most specifically, Nigeria. The studies on the SCMs/CRMs have concentrated mostly on concrete oblivious of the fact that the paste in the concrete constitutes 10 to 15 % of the total concrete

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volume, and the weakest point of attack by infiltrating chemicals. The quality of the paste determines the character of the concrete. The strength of the paste, in turn depends on the ratio of water to cement. Therefore, it is very important that the characteristics of the paste is known and the processes for durable paste constituent standards strictly applied. Darweesh [3] worked on the use of black liquor waste as cement admixture or cement and concrete admixtures. Some of his conclusions showed that the water of consistency was increased by 1.68 % to 13.12 % with OPC, and by 4.11 % to 13.85 % with LPC, in comparison with those of their planks. On the other hand, the PBL waste decreased the setting times (initial or final) with either OPC or LPC. With 3 % PBL the initial and final setting times decreased from 140 to 119 min and decreased from 255 to 231 min with OPC. With LPC pastes, these changes were from 148 to 128 min and from 266 to 148 min. He therefore, concluded that setting was faster with OPC than with LPC. Hence, PBL waste can act as an accelerator for cement pastes. Habeeb and Mahmud [4] and Abubakar [2] both worked on RHA. Dobiszewska and Beycioğlu [5] researched on waste basalt powder, while Samantasngha and Singh [6] was on slag blended geopolymer paste and mortar. Understanding the underlying mechanisms of the working of these cementitious pastes are key to optimize and transit the technology to the Nigerian construction industry.

Table 1 is a collection of literature of works on paste characteristics of different types of SCMs/CRMs with and without admixtures. The collections in Table 1 show that vital information on the paste, such as cement content, water quantity or water-cementitious materials, etc. used were omitted, and therefore, points to many inherent gaps in our experiential methods and omissions of important steps. Abubakar [2] for instance, mentioned consistency as a subtitle but never highlighted anything on it. Consistency is the water affinity of the material, and very important in the classification of the material. These are some of the gaps addressed in this work. Good experimental procedures that adheres to proper code interpretations and specifications, coupled with good documentations of procedures will boost confidence in the use of these lower grade materials. The study is on the paste characteristics of rice husk ash (RHA) and Conplast SP 430 [7] which are low grade materials. It is very important the RHA and CP-admixture with cement after setting, shall not undergo any appreciable change of volume to cause disruption of set and hardened mass. If this is allowed, it may cause serious difficulties for the durability of structures when such cementitious materials are used. The paste characteristics considered are soundness, consistency, and initial and final setting times. They were carried out experimentally with RHA as replacement materials in proportions of 0, 10, 20, 30, 40 and 50 % by wt. % of cement, and CP-admixture, at 5.7 mL by wt. % of cement to produce OPC-RHA-CP pastes.

Table 1. Tabulation of Past Research Results on Paste Characteristics

Researcher	Year	**Material**	**Repl. (%)**	**Mix**					**Paste Characteristics**			
				Cement (g)	Cement Type	Water (kg/m^3)	Admixture Type	Dosage	Sdness (mm)	Contcy (%)	Initial Setting (min)	Final Setting (min)
Elinwa and Mahmood [8]	2002	Sawdust ash	0	Not Specified	Ashaka Portland cement	*0.32	Nil	Nil	0.70	-	116	241
			5			*0.32			0.75	-	118	247
			10			*0.34			1.00	-	128	1267
			15			*0.35			1.15	-	135	283
			20			*0.37			1.25	-	160	298
			25			*0.39			1.30	-	170	318
			30			*0.42			1.45	-	190	337
Samantasinghar and Singh [6]	2019	GGBS	0	Not specified		Not specified	NaOH	16 M		39	700	1525
			20							38	180	400
			40							36	80	100
			60							34	50	80
			80							32	25	50
			100							31	20	20
Alkheder et al [9]	2016	Olive waste husk	0	Not specified		165.0					160.8	378
			3			161.2					181.9	380
			6			159.1					210.3	383
			9			156.3					221.6	387
			12			152.2					227.4	389
			15			148.6					231.0	391

				Mix					Paste Characteristics			
Researcher	Year	**Material**	**Repl. (%)**	Cement (g)	Cement Type	Water (kg/m^3)	Admixture Type	Dosage	Sdness (mm)	Contcy (%)	Initial Setting (min)	Final Setting (min)
Mbugua et al [10]	2016			500g			Gum Arabic	0			180	250
								0.3			310	490
								0.4			340	500
								0.5			390	590
								0.6			210	605
								0.7			150	600
								0.8			240	500
								0.9			100	495
								1.0			90	490
Mbugua et al [10]	2016			500g			Tard CE (Commercial)	0			180	250
								0.3			440	660
								0.4			400	790
								0.5			330	795
								0.6			325	796
								0.7			320	800
Dobiszewska and Beyciolu [5]	2017	Basalt powder	0		CEM 142R	*0.5				29	140	174
			1								150	167
			2								142	225
			3								164	225
			4								146	228
			6								164	249
			8								166	232
			10								170	265
Dobiszewska and Beyciolu [5]	2017	Basalt powder	0		CEM II/ A-S425R	*0.5				27	188	272
			1								193	276
			2								190	288
			3								186	287
			4								190	289
			6								201	291
			8								203	296
			10								202	311
Dobiszewska and Beyciolu [5]	2017	Basalt powder	0		CEMII/ A-V425R	*0.5				27	221	311
			1								230	305
			2								226	310
			3								226	308
			4								235	288
			6								192	302
			8								203	330
			10								246	324
Dobiszewska and Beyciolu [5]	2017	Basalt powder	0		CEM II/ B-V325R	*0.5				28	215	322
			1								205	329
			2								200	344
			3								220	335
			4								225	340
			6								218	353
			8								236	349
			10								232	372
Dobiszewska and Beyciolu [5]	2017	Basalt powder	0		CEM II/ B-V425N	*0.5				30	191	246
			1								185	252
			2								180	258
			3								207	253
			4								205	260
			6								192	267
			8								207	265
			10								202	262

Researcher	Year	Material	Repl. (%)	Mix					Paste Characteristics			
				Cement (g)	Cement Type	Water (kg/m^3)	Admixture Type	Dosage	Sdness (mm)	Contcy (%)	Initial Setting (min)	Final Setting (min)
Elinwa, AU [11]	2016	Hospital waste ash	0	Not given	Ashaka Portland cement				12.2	29	45	496
			10						11.0	34	185	876
			20						9.6	36	300	985
			30						11.3	39	490	1075
			40						13.3	41	690	11000
Elinwa and Abdulrazaaq [12]	2020	PVC powder	0	300	OPC					32.5	90	190
			5							32.8	96	253
			10							33.2	99	271
			20							34.0	105	280
			30							36.8	108	290
			40							39.5	113	300

2. Materials

The materials used are Ashaka Portland cement, rice husk ash and Conplast SP 430 as the plasticizer. The cement conforms to BS EN 197 Part 1 [13], and was procured at the local market in Bauchi, Nigeria. The rice husk ash used for the production of the ash was collected as a waste threshed out and separated from the rice grains. Therefore, it was collected as a waste and calcined in the kiln of the Industrial Department of the university at a temperature range of 400 ^oC to 600 ^oC, grinded using pestle and mortar, and sieved using a sieve size of 150 µm. The physical and chemical properties were carried out in accordance with ASTM C 618-12 [14]. The cement chemical properties were tested at Ashaka Cement Company in Ashaka, Gombe State. The physical and chemical properties of the 'Ashaka' OPC and RHA are shown in Table 2.

Table 2. Physical and Chemical Properties of Ashaka Portland Cement and Rice Husk Ash

Parameter	Cement	Rice Husk Ash
Physical Properties		
Specific gravity	3.12	1.934
Fineness (kg/m^2)	330	20.2 (%)
Bulk density (kg/m^3) [ref]	830-1650	
Consistency (%)	29	
Initial setting time (min)	65	
Final setting time (min)	275	
Soundness (mm)	2.5	
LOI	-	7.0
Chemical Properties		
SiO_2	19.68	73.97
Al_2O_3	6.44	7.03
Fe_2O_3	3.32	1.19
CaO	60.92	0.96
MgO	0.97	2.45
SO_3	2.28	3.14
K_2O	0.85	2.78
Na_2O	0.12	0.90
TiO_2	0.30	Nil
P_2O_5	0.20	6.18
Mn_2O_3	0.20	1.40

The superplasticizer used is Conplast SP 430 [7] and conforms to ASTM-C-494-92 [15]. The extracts from the manufactures literature describes it as a chloride free, superplasticizing admixture based on selected sulphonated naphthalene polymers. It is a brown solution and disperses in water. It is suitable for use with all types of Portland cements and cement replacement materials such as rice husk ash. Table 3 shows the typical properties of Conplast SP 430.

Table 3. Typical Properties of Conplast SP 430

Parameter	Description
Appearance	Brown liquid
Specific gravity	1.18 @ 25oC
Chloride content	Nil to BS 5075/BS: EN934
Air entrainment	Less than 2 % additional air is entrained at normal dosages

3. Experiment

The soundness, standard consistency and initial and final setting times were carried out using ordinary Portland cement (OPC) paste containing rice husk ash (RHA) and Conplast SP 430 (CP-admixture) in proportions of 0, 10, 20, 30, 40, and 50 %, respectively. The control mix was designated as MR-00, reflecting a paste without RHA or CP-admixture. The other paste compositions are labelled as MR-10/50 for OPC-pastes containing RHA only, and MRCP-10/50 for OPC-pastes containing both RHA and CP, respectively. A cement content of 300 g was used with RHA replacements of cement by wt. %, and/or, with a CP-admixture dosage of 5.7 mL wt. % of cement. These mixes were used to study their effects on the soundness, consistency and initial and final setting times.

Soundness of cement is a quality assurance test of cement. This was carried out to examine expansion due to the presence of free lime and magnesia (MgO) in the cement. This is important to affirm that the cement after setting shall not undergo a large expansion to cause disruption of the cement used. It was carried out using the Le-Chateliers apparatus and consists of a small split cylinder of spring brass to other non-corrodible metal of 0.5 mm thickness forming a mold of 30 mm internal diameter and 30 mm high. On either side of the split, two indicators are brazed suitably with pointed ends made of 2 mm diameter brass wire in such a way that the distance of these ends to the centre of the cylinder is 165 mm. The split cylinder was kept between two glass plates and the temperature in the laboratory was almost 29^{o}C, and the relative humidity was 62 %. The immersed Le-Chatelier molds were raised to a temperature of approximately 27 ^{o}C, and measured with a Vernier caliper.

The consistency of a binder paste is the measure of the degree of wetness or fluidity of the prepared paste. The objective of conducting this test is to find out the amount of water needed to be added to the cement to get a paste of normal consistency. It is defined as that consistency that will permit the Vicat plunger to penetrate to a point 5 to 7 mm from the bottom of the Vicat mold. Pastes with the above compositions were used for this test. The precaution taken was that gauging was kept below 5 min to avoid setting before time. The test was conducted in accordance with BS 4550: 1978 [16] specification, and evaluated using Equation (1):

$$Standard\ Consistency\ (\%) = \frac{Weight\ of\ water\ added}{Weight\ of\ cementitious\ material}\ x\ 100 \quad (1)$$

The initial setting time is the time when cement paste starts hardening while the final setting time is the time when cement paste has hardened sufficiently in such a way that a 1 mm needle makes an impression on the paste in the mold but 5 mm needle does not make any impression. Setting time is the is the time required for stiffening of cement paste to a defined consistency., and thus initial setting time is important for transportation, placing and compaction of cement concrete. It is required to delay the process of hydration or hardening. The Vicat's apparatus was used for this test and conducted in accordance with BS 12: [1] and BS 4550 [16] specifications respectively. The initial and final setting times are calculated as:

$$Initial\ Setting\ Time = T_2 - T_1$$
$$Final\ Setting\ Time = T_3 - T_1 \quad (2)$$

Where,

T_1= Time at which water was first added to cement

T_2= Time when needle failed to penetrate 5 mm to 7 mm from bottom of the mold

T_3= Time when the needle made an impression but the attachment failed to do so.

The results of the soundness, consistency and initial and final times of setting are shown in Table 4.

Table 4. Soundness, Consistency and Setting Times of RHA-CP-OPC Paste

Mix No	Conplast (mL)	Soundness (mm)	Consistency (%)	Setting Times (Min)	
				Initial	Final
MR-00	Nil	7.0	36.0	120.0	180.0
MR-10	Nil	8.0	39.0	130.0	219.0
MR-20	Nil	8.0	55.0	152.0	249.0
MR-30	Nil	10.0	58.0	160.0	271.0
MR-40	Nil	10.0	101.0	210.0	345.0
MR-50	Nil	10.0	112.0	276.0	397.0
MRCP-00	5.7	9.0	34.0	128.0	186.0
MRCP-10	5.7	9.3	37.0	137.0	225.0
MRCP-20	5.7	9.7	50.0	159.0	258.0
MRCP-30	5.7	9.9	55.0	166.0	278.0
MRCP-40	5.7	9.8	60.0	216.0	352.0
MRCP-50	5.7	9.5	65.0	284.0	405.0

Table 5. Percentage Difference of OPC-RHA-CP Paste

Mix-Combination	Replacement (%)	Soundness (mm)	Consistency (%)	Initial Setting	Final Setting
Control Paste with Control with CP (MR-00 and MRCP-00) – ***Mix 0***	0.00	28.6	-5.6	6.7	3.3
Control paste and Paste with RHA (MR-00 and MR-10, 20, etc) – ***Mix 1***	10 20 30 40 50	14.3 14.3 42.9 42.9 42.9	8.3 52.8 61.0 180.6 211.1	8.3 26.7 33.3 75.0 130.0	21.7 38.3 50.6 91.7 120/6
Control Paste with CP and RHA with CP (MRCP-00 and MRCP-10, 20, etc) – ***Mix 2***	10 20 30 40 50	3.3 7.8 10.0 8.9 5.6	8.8 47.1 61.8 76.5 91.2	7.0 24.2 29.7 68.8 121.9	21.0 37.7 49.5 89.2 117.7
Paste with RHA and RHA paste with CP (MR-10, 20, … and MRCP-10, 20, etc) – ***Mix 3***	10 20 30 40 50	16.3 21.3 -1.0 -2.0 -5.0	-5.1 -10.0 -5.5 -40.6 -42.0	5.4 4.6 3.8 2.9 2.9	2.7 3.6 2.6 2.0 2.0

4. Discussion

What gives cement it's property is the CaO content and it has a cementing property. This is approximately 61 %. The SiO_2 in the cement is only approximately 20 %. However, for the RHA the SiO_2 is 74 % and the CaO is just approximately 1 %. The sum of the SiO_2 + Al_2O_3 + Fe_2O_3 in the RHA is approximately 82 %, which is greater than the 70 % specified in ASTM for pozzolanicity. The limits of the MgO and Na_2O both in the cement and RHA are 0.97/0.12 and 2.43/0.90. These are both less than the limits set for them by BS 12 (1999), that is 0.1 to 4.0 and 0.2 to 1.3, respectively. Can be said to be okay. The K_2O content and the LOI are 2.8 % and 7 % respectively. A well burnt RHA has an average composition 2 % K_2O and 5 % carbon (LOI). Therefore, within the experimental errors the RHA can be said to be okay.

Figures labeled 3a and 4a are plots of the data on paste characteristics of the OPC-RHA-CP-admixture cement paste, while Figures 3b and 4b are plots taken from Table 5 showing the percentage differences recorded for each mix combinations (***Mix 0 to Mix 3***). The performances of these pastes reflect the characteristics of the RHA which are dependent on three factors: (i) the composition of the rice husk, (ii) the burning temperature and, (iii) the burning time. Under controlled burning conditions (as in this case) the volatile organic matter in the rice husk consisting of cellulose and lignin are removed and the residual ash is predominantly amorphous silica with a (microporous) cellular structure as shown in Figures 1 and 2, the microstructure and diffractogram of the RHA.

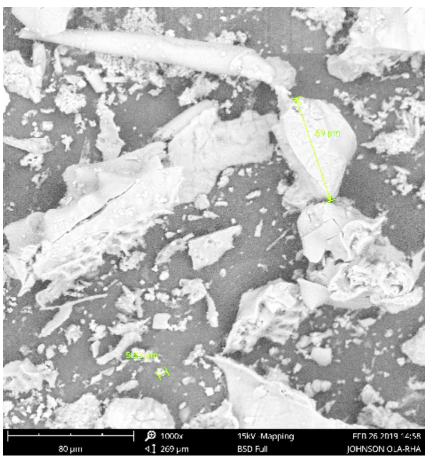


Figure 1. Micrograph of RHA

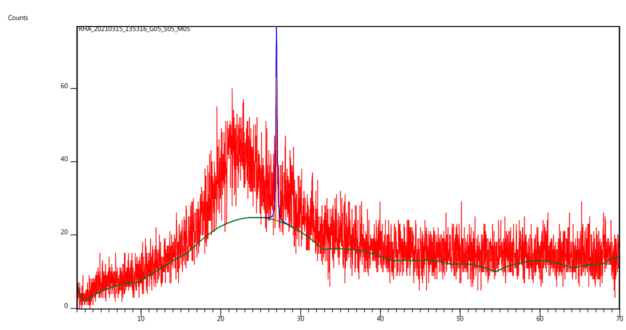
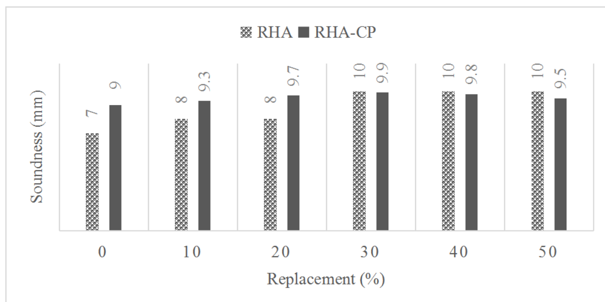
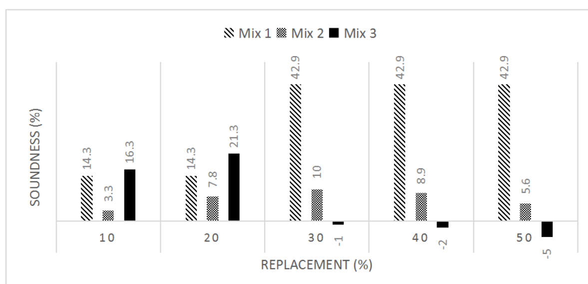


Figure 2. XRD Diffractograme of RHA

The soundness of the OPC-RHA-CP paste is shown in Figure 3. It shows that for all combinations of the paste the soundness was ≤ 10 %. Therefore, it can be said that the addition of RHA and/or CP-admixture to OPC paste will not cause unsoundness and after setting will not undergo any appreciable change of volume. The addition of 5.7 mL of CP-admixture by wt. % of cement to OPC increased the soundness by approximately 28 %. The difference between the control mix (MR-00) and the mix containing RHA (MR-10 to MR-50) without CP-admixture showed an increase of 14.3 % at 10 and 20 % replacements respectively, and remained constant at 42.9 % at 30 to 50 % replacements. The same comparison is made for the case when the control paste containing CP-admixture (MRCP-00) and that containing RHA with CP-admixture (MRCP-10 to MRCP-50). The comparison shows increases of 3.3 at 10 % with a peak value of 10 % at 30 % replacement, and fell to a value of 5.6 % at 50 % replacement. However, the case of adding CP-admixture to MR-00 and MR-10 to MR-50, and compared shows that it has drastic effects at higher replacement levels of RHA. At 10 t0 20 % replacements there were increases of 16. 3 and 21.3 % respectively, but drastically reduced from 30 to 50 % replacements to -1.0 to -5.0 %.



(a) Soundness Plot

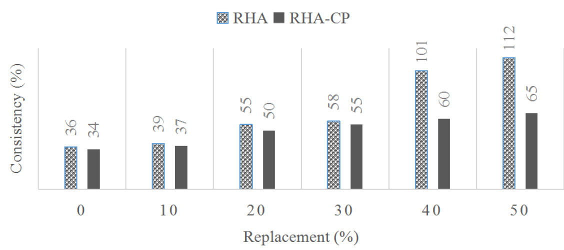


(b) Soundness Difference

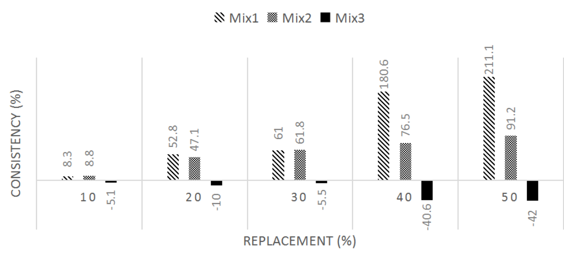
Figure 3. Soundness of RHA-CP-OPC Paste

Figure 4 is the consistency of OPC-RHA-CP cement paste. The consistency is the water affinity of the cementitious material. This decreased by 5.6 % when CP-admixture was added to the control mix (MR-00).

One of the advantages of water reducing admixture such as naphthalene sulphonated is that it reduces the water-cementitious ratio while keeping the concrete workable. For the mix without the CP-admixture (MR-00 and MR-10 to MR-50) the water requirement increased from 8.3 to 211.1 %. RHA contains a cellular, honeycomb morphology of amorphous silica and this morphology results in high water absorption. Therefore, the increase in water affinity can be attributed to this rough texture and amorphous nature of the RHA. We therefore, need more water for workability. This behavior is further confirmed for the same mix but with CP-admixture (MRCP-00 and MRCP-10 to MRCP-50 where the water for workable OPC paste decreased from 8.8 to 91.2 %.



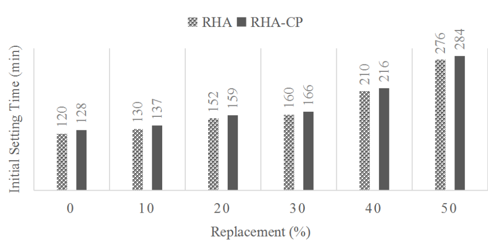
(a) Consistency Plot



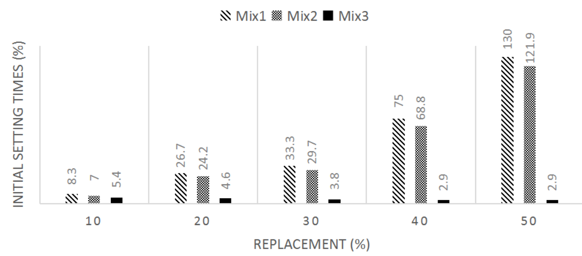
(b) Percentage Difference

Figure 4. Consistency of RHA-CP-OPC Paste

The situations with the initial and final setting times are not different (Figures 5a and 5b) and (Figures 6a and 6b), respectively. Both the RHA and CP-admixture increased the setting times in various degrees as shown. It therefore goes to show that these materials are retarders. Retarders are useful additives especially for hot weather concreting. This, also advances one of the characteristics of the CP-admixture that it improves cohesion, and particle dispersion minimizes segregation and bleeding with increased workability.

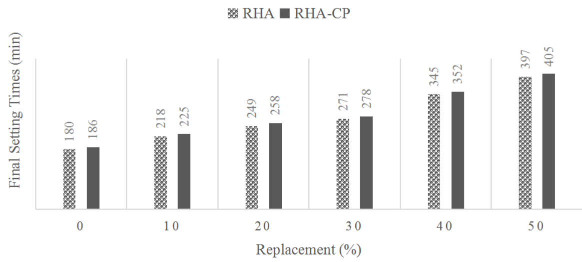


(a) Initial Setting Time Plot

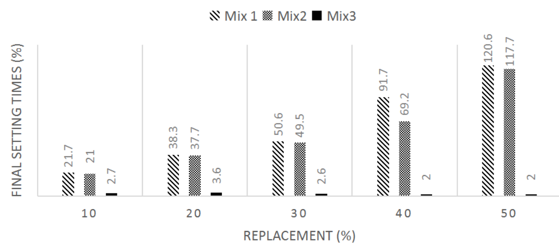


(b) Percentage Difference

Figure 5. Initial Setting Time of RHA-CP-OPC Paste



(a) Final Setting Time Plot



(b) Final Setting Time Difference

Figure 6. Final Setting Time of RHA-CP-OPC Paste

Statistical Characteristics and Linear Regression Model of OPC-RHA-CP Paste

Table 6 shows the statistical characteristics of the paste. It shows the mean, standard deviation etc of the paste. The mean value characterizes the central tendency or location of the data, while the coefficient of variation provides a general feeling about the performance of the method. It is the distribution of data points in a data series around the mean and thus, expresses the variation as a percentage of the mean. The larger the coefficient of variation, the greater the spread in the data. The standard error of the mean (SE Mean) estimates the variability between sample means, and the standard deviation and thus, establishes a benchmark for estimating the overall variation of a process. Whereas the standard error of the mean estimates the variability between samples, the standard deviation measures the variability within a single sample. A higher standard deviation value indicates greater spread in the data. From the results are achieved in Table 6 it can be concluded that both the RHA and CP-admixture are compatible with the 'Ashaka' Portland cement.

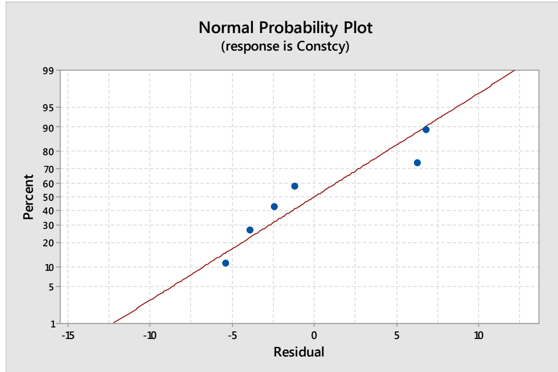
Table 6. Statistical Characteristics of OPC-RHA-CP Paste

Mix	Variable	Mean	SE Mean	StDev	Variance	CoefVar
RHA	Soundness	8.8	0.5	1.33	1.8	15,1
	Consistency	66.8	13.1	32.1	1030.2	48.0
	Initial Setting	174.7	58.7	58.7	3445.9	33.6
	Final Setting	276.7	80.9	80.9	6546.7	29.3
RHA-CP	Soundness	9.5	0.1	0.3	0.1	3.6
	Consistency	50.2	5.1	12.5	155.0	24.8
	Initial Setting	181.7	24.0	58.8	3457.1	32.4
	Final Setting	284.0	33.2	81.3	6612.4	28.6

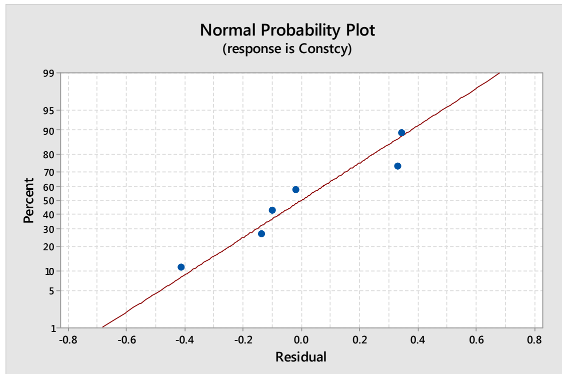
Tables 7 and 8 are the linear regression model characteristics of the OPC-RHA-CP-admixture paste. The study on the experimental data used three regression models: (i) no-transformation, (ii) λ = 0.5 transformation, and (iii) box-cox transformation. The model characteristics are shown in the Tables 7 and 8, respectively, and the normality plot for the various mixes shown in Figure 7. All the models used seem to be adequate but the box-cox transformation shows more appropriateness compared with the no-transformation and λ = 0.5, based on the quality of the regression model characteristics achieved.

Table 7. Model Characteristics of OPC-RHA Paste

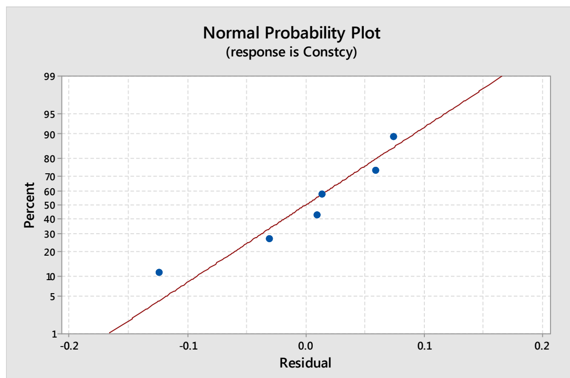
Parameter	RHA-CP-OPC Paste Characteristics		
	MODELI	MODEL II	MODEL III
Regression	*p = 0.040*	0.035	0.034
Soundness	*p = 0.550*	0.561	0.604
Initial Setting	*p = 0.773*	0.598	0.465
Final Setting	*p = 0.285*	0.225	0.192
Constant	*p = 0.678*	0.305	0.029
Model Summary	S (8.2782); R^2 (97.3 %)	*S* (0.4630); R^2 (97.7 %)	*S* (0.1128), R^2 (97.72 %),
Transformation	None	λ = 0.5	Box –Cox Rounded λ = 0 Estimated λ = 0.0235 95 % CI for λ = (-1.2430, 1.3850)
Regression Equation			



RHA-No Transformation



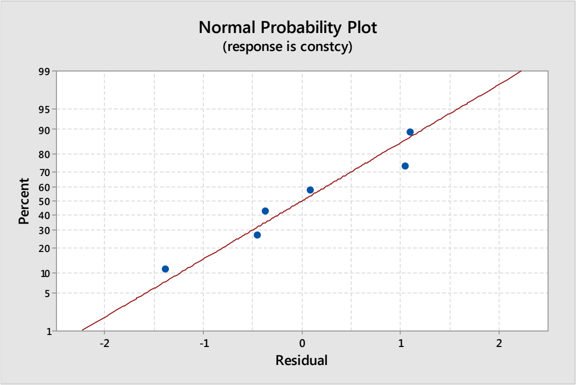
RHA: λ = 0.5



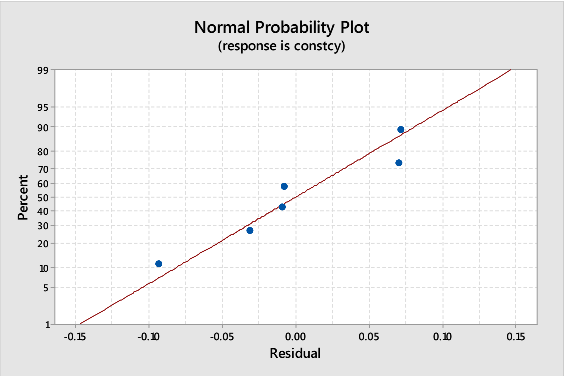
RHA: Box-Cox Transformation (Rounded λ = 0)

Table 8. Model Characteristics of OPC-RHA-CP Paste

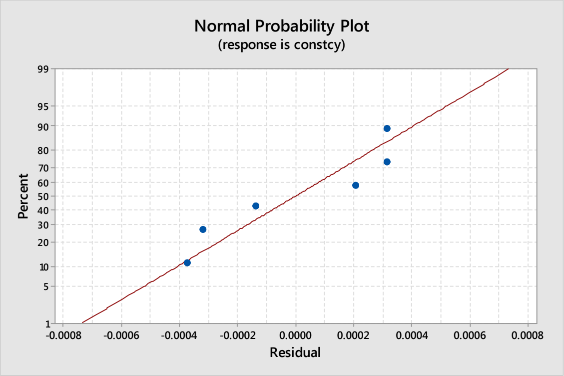
Parameter	RHA-CP-OPC Paste Characteristics		
Regression	*p = 0.009*	0.007	0.004
Soundness	*p = 0.043*	0.031	0.014
Initial Setting	*p = 0.124*	0.103	0.067
Final Setting	*p = 0.362*	0.300	0.179
Constant	*p = 0.046*	0.305	0.029
Model Summary	S (1.5141); R^2 (99.4 %), $R^{2(pred)}$ (84.2 %)	*S* (0.0996); R^2 (99.5 %) $R^{2(pred)}$*(86.1%)*	*S* (0.1128), R^2 (97.72 %), $R^{2(pred)}$ (93.3%)
Transformation	None	λ = 0.5	Rounded λ = -1 (Box-Cox) Estimated λ = - 0.866784 95 % CI for λ = (-2.31928, 1.46672)
Regression Equation			



RHA-CP: No Transformation



RHA-CP: λ = 0.5



RHA-CP: Box-Cox Transformation (Rounded λ = 0)

Figure 7. Normality Plots for the Regression Models

5. Conclusions

An experimental investigation of the effects of using supplementary cement materials (SCM), in this case RHA, and an admixture, (Conplast SP 430) which is plasticizer, to evaluate the paste characteristics of mixes made with and without RHA, and CP-admixture as the case may be. The conclusions are:

i. RHA is pozzolanic and the limits of MgO and Na_2O are within the code's specifications. Using RHA, and/or RHA with CP-admixture will not cause unsoundness, and will not undergo any appreciable change after setting.

ii. A mixture of RHA alone will increase the water requirement because of the morphology of the RHA which encourages water absorption.

iii. Addition of CP-admixture to RHA mix will reduce the water affinity of RHA.

iv. The setting times will be affected by both the addition of RHA and CP-admixture which will allow adequate time for concreting before it sets.

Recommendation

The use of RHA with CP-admixture is recommended for good flow of the paste.

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