International Journal of Engineering & Technology
CENTRE OF PROFESSIONAL RESEARCH PUBLICATIONS
ISSN 2049-3444

International Journal of Engineering and Technology Volume 3 No. 8, August, 2013

Effects of Rice-Husk Ash as Partial Replacement for Cement on Compressive Strength of Recycled Aggregate Concrete

Akinkurolere O. O.
Department of Civil Engineering, Faculty of Engineering, Ekiti State University,
Ado-Ekiti, Nigeria.

ABSTRACT

The cost of cement and other construction materials is on the increase in developing countries like Africa. This problem is further aggravated by the incessant scarcity of the cement due to high exchange rate of the local currency (which discourages importation of cement and other construction materials). Furthermore, the source of raw materials for building industries is clearly changing in many countries and more attention is being given to environmental safety regulations. Therefore, the recycled concrete aggregate has been widely reused for making different construction materials. And this is believed to have positive impact on the reservation of natural resources, prevention of environmental pollution, and cost-saving consideration of construction project.

Experimental studies were carried out to evaluate the influence of Rice-Husk Ash on the Compressive strength of Recycled Aggregate Concrete. The experimental program consisted of testing 100 x 100 x 100mm concrete cubes. The experimental variables used were the Water-cement ratio, Recycled Aggregate, and Rice-Husk Ash as partial replacement for cement. Orthogonal Array table with three levels and three factors was used to prepare the mixing proportions, and Analysis of Variance and significance test with F statistic were used to check the existence of interaction and level of significance. The results indicate that the orders of significance of the three factors are: Recycled Aggregate content, Rice-Husk Ash content and Water-Cement ratio, respectively. The effects of these variables on the compressive strength of concrete are presented and discussed.

Keywords: *Recycled Aggregate, Concrete, Water-cement ratio, Rice-Husk Ash.*

I. INTRODUCTION

Source of raw materials for building industries is clearly changing in many countries as more attention is being paid to environmental regulations. Cost of dumping either residue of fresh and hardened rejected units in the precast concrete plants is expected to keep rising. Therefore, a considerable concern was raised in using recycled concrete as a new source of aggregate in concrete industry. Aggregate recycled gained importance because it protects natural resources and eliminate the need for disposed by using the readily available concrete as aggregates (Alizera *et al*., 2007; Anwar *et al*., 2001; Chindaprasirta *et al*., 2007; Coutinho, 2002; Deepa, 2006; Della *et al*., 2002).

In developing countries, there are increasing demands for construction materials for the execution of buildings and civil engineering projects, but the major conventional materials are not readily available. For this reason, the natural deposits are becoming extinct and therefore, the construction industry is either spending much on acquiring materials which results to expensive act of importation. It is therefore of utmost importance that research constitutes and universities should look into the possibilities of recycling the construction and demolition wastes (C&D) and turn them into construction materials.

Rice husk Ash has been known to successfully improve the engineering properties of cohesive soils by its mixing with soil. Rice Husk Ash is a product which can be obtained from electric power plants. It is one of the residues generated in combustion, and comprises the fine particles that rise with the flux gases. The high and continuous increase in the cost of cement have made it imperative to search for other alternatives (Feng et al,2004; Zhang et al,1996).

II. MATERIALS AND METHODS

Collection and Production of Aggregates Used

Natural aggregates (gravels) were obtained from construction sites which were produced by quarrying i.e. blasting of big rocks/boulders into standard coarse aggregate sizes. The recycled coarse aggregates were obtained by crushing old concrete blocks into smaller sizes and sieved out the finer aggregates away. Natural fine aggregates (River sand) were used too, it passed through a desired sieve to prevent the unwanted particles.

Mixing of Concrete

All concrete mix designs used in this project were calculated using absolute volume method. All mixing was conducted under laboratory conditions using concrete mixer. For the concrete mix, 108 samples 0f 150 mm cubes, were cast .The 150mm cubes were used to test the compressive strength. All specimens were cast into iron moulds and compacted in layers using iron rods. The specimens were cured in air in a vibration free environment for a period of 24-48 hours before they were demolded. After demolding, they were then transferred to bath tub until test ages were reached.

Design of Experiment

Taguchi's approach was adopted in order to reduce the numbers of trials required to gather necessary data. Orthogonal arrays (OA) L_9, 3^3 series (as shown in Table 1) was used to reduce the number of tests. In this study, the three levels considered which formed the column of the orthogonal array were the changes in water/cement ratio which are 0.45, 0.50 and 0.55, respectively, while the test three factors on the orthogonal rows were considered. The three test factors were the changes in recycled aggregates contents, Rice Husk Ash (RHA) and amount of water to cement ratio (W/C) added for each run respectively. The total number of cubes casted was 108. Analysis of Variance (ANOVA) - was used to analyze the results. After the ANOVA is completed, the F statistic of any specific control factor A, say F_A, which is defined as the ratio between the sum of variance square for the A control factor and the sum of error variance square, was obtained. The value of F_A is used for the significance test. The bigger the F_A, the larger the significant influence of control factor A will be. The significance level is divided into two kinds: (1) significant (α = 5%) and (2) very significant (α = 1%)

Table 1: Summary of Test Factors and Levels for OA L_9

Level	Factors		
	Water-Cement (W/C)	Recycled Aggregate (RA)	Rice Husk Ash(RHA)
1	0.45	0%	0%
2	0.50	50%	20%
3	0.55	100%	30%

III. RESULTS

The crushing load of each sample was obtained after 7th, 14th, 21st and 28th days of curing and the average crushing load was arrived at by the addition of the crushing load for each variation and divided by the total number of cubes of the variation in concern. Tables 1-3 show the summary of compressive strength test results for 7, 14, 21 and 28th -day.

Table 1: Summary of L_9 (3^3 Series) Orthogonal Array Test Results for Compressive Strength

Test No.	Average Compressive Strength f_c (N/mm^2)				% Strength Increment			S/N Ratio for Average Compressive Strength			
	7-Day	14-Day	21-Day	28-Day	7-14 Days	14-21 Days	21-28 Days	7-Day	14-Day	21-Day	28-Day
1	15.03	20.14	22.74	24.74	5.11	2.6	2.00	23.51	26.08	27.14	21.74
2	11.26	13.11	14.00	15.99	1.85	0.89	1.99	20.9	22.35	22.92	27.87
3	8.52	9.26	13.33	13.55	0.74	4.07	0.22	18.58	19.33	22.5	24.08
4	14.52	19.99	22.15	22.89	5.47	2.16	0.74	23.22	26.02	26.91	22.64
5	11.11	13.85	14.96	16.96	2.74	1.11	2.00	20.81	22.83	23.5	27.19
6	12.44	16.22	17.71	20.14	3.78	1.49	2.43	21.66	24.2	24.96	24.59
7	13.77	18.37	21.85	22.59	4.6	3.48	0.74	22.77	25.28	26.79	26.08
8	11.70	14.73	17.33	18.96	3.03	2.6	1.63	21.84	23.36	24.78	27.08
9	9.11	9.60	12.22	13.33	0.49	2.62	1.11	19.19	19.65	21.74	25.56

Table 2: Analysis of Variance (ANOVA) for Compressive Strength of Orthogonal Array L_9 (3^3 Series)

	Factor	DOF	SS	Contribution factors of SS (%)	F ratio	Prob >F
7-Day	W/C	2	2.09	5.13	2.05	0.3280
	RA	2	30.08	73.79	29.49	0.0328*
	RHA	2	7.57	18.57	7.42	0.1187
	Error	2	1.01	2.48	Prob >F	-
	Total	**8**	**40.76**	**100**	**-**	**0.0732**
14-Day	W/C	2	12.36	9.41	3.60	0.2173
	RA	2	97.19	74.06	28.33	0.0341*
	RHA	2	18.24	13.90	5.31	0.1583
	Error	2	3.43	2.63	Prob >F	
	Total	**8**	**131.23**	**100**	**-**	**0.0764**
21-Day	W/C	2	4.00	3.03	1.63	0.3809
	RA	2	108.74	82.45	44.16	0.0221*
	RHA	2	16.67	12.65	6.77	0.1287
	Error	2	2.46	1.87	Prob >F	-
	Total	**8**	**131.88**	**100**	**-**	**0.055**
28-Day	W/C	2	6.56	4.79	2.39	0.2995
	RA	2	99.71	72.80	36.22	0.0269*
	RHA	2	27.93	20.39	10.15	0.0897
	Error	2	2.75	2.02	Prob >F	-
	Total	**8**	**136.96**	**100**	**-**	**0.0591**

Table 3: L_9 (3^3 Series) Orthogonal Analysis for Compressive Strength

	Factors	E1*	E2*	E3*	R*
7- Day Compressive Strength f_c(Mpa)	W/C	11.60	12.69	11.75	1.09
	RA	14.44	11.58	10.02	4.42
	RHA	13.28	11.63	11.13	2.15
14- Day Compressive Strength f_c (Mpa)	W/C	14.17	16.69	14.23	2.52
	RA	19.50	13.90	11.69	7.81
	RHA	17.03	14.23	13.83	3.20
21-Day Compressive Strength f_c (Mpa)	W/C	16.90	18.27	17.13	1.37
	RA	22.25	15.43	14.42	7.83
	RHA	19.26	16.12	16.71	3.14
28-Day Compressive Strength f_c (Mpa)	W/C	18.09	20.00	18.29	1.91
	RA	23.40	17.30	15.67	7.73
	RHA	21.28	17.40	17.70	3.88

*E1, E2, E3, E4 – Average effect of three factors at levels 1, 2 and 3.
*R –Rank of significance among the factors.

IV. DISCUSSION

One major aim of this research is to evaluate the compressive strength of concrete containing natural and recycled aggregates at various proportions with partial replacement of cement by Rice Husk Ash. Compressive strength tests on standard 150mm concrete cubes were carried out at ages up to twenty-eight days after initial curing.

The strengths and the ratios of compressive strength development of the recycled concrete for the nine sets of tests are presented in Table 1. The table makes it clear that the strength development speed is faster for recycled concrete with a lower water-cement ratio. Also in this table, the levels corresponding to the highest S/N ratios are chosen for each factor to indicate best condition which is test number one and five. However, it is worth noting that the differences in strength of concrete containing recycled aggregates and those without recycled aggregates reduces with age of curing, particularly at 28 days. Also, at 28 days, it appears that replacement with recycled aggregates up to 50% does not have much adverse effect on the compressive strength of recycled aggregate concrete. In addition, at this dose, the rate of increase in strength of recycled aggregate concrete was higher than that of natural aggregate concrete. This might be due to angular shape and rough texture of recycled aggregates which might have provided better bonding and interlocking between the cement paste and the recycled aggregates themselves compared with those of natural aggregates. Another major cause for this trend might be the absorbent nature of the recycled aggregates which absorbed some of the water during mixing and caused a reduction in the actual water-cement ratio of the recycled aggregate concrete mixes.

The analysis of variance (Table 2) gave a clearer picture of the importance of each factor. From the table, the most significant factors for the development of the strength of recycled aggregate concrete was recycled aggregate contents followed by addition of Rice Husk Ash, and this agrees with previous works (Della *et al*., 2002; Ganesan *et al*., 2007; Habeeb and Fayyadh, 2009).

Table 3 further explains the importance of each component of the concrete mixture. From the table, the order of significance of the three factors is recycled aggregate content, Rice-Husk Ash content and water-cement ratio, respectively.

ACKNOWLEDMENT

The author will like to acknowledge the efforts of Miss Omole Yetunde for her assistance in collecting materials and generating the data.

REFERENCES

[1]. Alireza N. G., Suraya A. , Farah Nora A.A. , Mohamad A. M.(2010). “Contribution of Rice Husk Ash to the Properties of Mortar and Concrete: A Review

[2]. Anwar, M., Miyagawa, T., and Gaweesh, M. 2001. Using rice husk ash as a cement replacement material in concrete. In the Proceedings of the 2001 first international Ecological Building Structure Conference. pp. 671- 684.

[3]. Chindaprasirta, P., Kanchandaa, P., Sathonsaowaphaka,A., and Caob, H.T. (2007), Sulfate resistance of blended cements containing fly ash and rice husk ash. Construction and Building Materials. 21(6): 1356-1361.

[4]. Coutinho J.S. (2002). The benefit of Rice husk ash in improving the durability of concrete structures.Cement and concrete composites, 25(1): 51-59.

[5]. Della, V.P., Kuhn, I., Hotza, D. (2002). Rice husk ash as an alternate source for active silica production.Materials Letters. 57(4): 818–821.

[6]. Feng, Q., Yamamichi, H., Shoya, M., and Sugita, S. 2004.Study on the pozzolanic properties of rice husk ash by hydrochloric acid pretreatment. Cement and Concrete Research. 34(3): 521–526.

[7]. Ganesan, K., Rajagopal, K., and Thangavel, K. 2008. Rice husk ash blended cement: Assessment of optimal level of replacement for strength and permeability properties of concrete. Construction and Building Materials. 22(8): 1675–1683.

[8]. Habeeb, G.A., and Fayyadh, M.M. 2009. Rice Husk Ash Concrete: the Effect of RHA Average Particle Size on Mechanical Properties and Drying Shrinkage. Australian Journal of Basic and Applied Sciences. 3(3): 1616-1622.

[9]. Zhang, M.H., Lastra, R., and Malhotra, V.M. 1996. Ricehusk ash paste and concrete: Some aspects of hydration and the microstructure of the interfacial zone between the aggregate and paste. Cement and Concrete Research. 26(6): 963-977.

