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COMPARATIVE STUDY ON THE EFFECT OF GRINDED RICE HUSK AND RICE HUSK ASH ON COMPRESSIVE STRENGTH OF CONCRETE

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Abstract: Comparative study between Grinded Rice Husk (GRH) and Rice Husk Ash (RHA) effect on concrete performance were performed in this research. Ordinary Portland cement (OPC) cement was partially replaced by GRH at 5% and 10%, and RHA at 5%, 10%, and 20% by weight of cement for a specific water/cement ratio. Compressive strength for 7, 14, and 28 days were determined. The control mix at 28 days had a peak compressive strength of 49.07N/mm^2 while cement partially replaced by GRH at 5% and 10% were 47.84N/mm^2 and 45.47N/mm^2 respectively and cement partially replaced by RHA at 5%, 10%, 20% were 53.24N/mm^2, 50.24N/mm^2, and 46.53N/mm^2 respectively at 28 days. The results of the experiments showed that at 5% RHA partial replacement had the optimum compressive strength obtained at 28 days. Replacement of cement with GRH and RHA lead to improvement in the compressive strength of concrete and overall cost of construction.
Keywords: comparative study, grinded rice husk, rice husk ash, partial replacement, compressive strength

INTRODUCTION

Recent work carried out on the formulation and manufacture of concrete has led to the development of various classes with improvement in its quality and properties. Typical concrete is a mixture of fine aggregate (sand), coarse aggregate (rock), cement, and water. The aggregate in the concrete is basically silica, but unfortunately it reacts too slowly, due to its reduced total surface area. Cement gives off lime as it hardens and this lime will inevitably react with silicates or alumino-silicates [1].

The use of pozzolans in concrete helps the lime produced in the hardening of the concrete to slowly react with the aggregate, producing gels. These gels are expansive, and they just fill the voids with a slight pressure thus avoiding water penetration and leaching. Concrete with sawdust ash as pozzolanic material gain strength rapidly at later stages, [2].

Rice plant is one of the plants that absorbs silica from the soil and assimilates it into its structure during the growth [3]. Rice husk is the outer covering of the grain of rice plant with a high concentration of amorphous silica, generally more than 80-85% [4]. It is responsible for approximately 30% of the gross weight of a rice kernel and normally contains 80% of organic and 20% of inorganic substances. Rice husk is produced in millions of tons per year as a waste material in agricultural and industrial processes.

Nigeria is the 19th largest producer of rice in the world with over 3.4 million metric tonnes of paddy rice produced annually and 63,400 metric tonnes of rice husk generated with a potential for production of at least 121,212 metric tonnes of rice husk ash from rice husk generated. This enormous waste is presently not being harnessed productively in the country other than burning, a major air pollution activity and indiscriminate dumping that cause environmental hazard.

Rice husk in large quantities are grinded together to produce ground rice husk (GRH), and rice husk ash (RHA) is a byproduct of burned rice husk at higher temperature, it can contribute about 20% of its weight to RHA after incineration [5]. So for every 1000 kg of paddy milled, about 220 kg (22%) of grinded husk produced, and when this husk is burnt in the boilers, about 55 kg (25%) of RHA is generated. RHA is a highly pozzolanic material [6], the non-crystalline silica and high specific surface area of the RHA are responsible for its high pozzolanic reactivity. RHA has been used in lime pozzolana mixes and could be a suitable partly replacement for Portland cement (7, 8, 9, 10). RHA is also classified in the same category of highly active pozzolans as Silica Fume [11]. The mean particle size of RHA generally ranges from 5 to 10 μm. However, RHA has a very high specific surface area ranging from 20 to 260 m^2/g [12] which is attributed to its porous structure [13, 14]. Mehta and Pirth [15], investigated the use of RHA to reduce temperature in high strength mass concrete and got result showing that RHA is very effective in reducing the temperature of mass concrete compared to OPC concrete. Mehta [16], later reported that ground RHA with finer particle size than OPC improves concrete properties, including that higher substitution amounts results in lower water absorption values and the addition of RHA causes an increment in the compressive strength.

This RHA in turn contains around 85%-90% amorphous silica. So for every 1000 kg of paddy milled, about 220 kg (22%) of husk is produced, and when this husk is burnt in the boilers, about 55 kg (25%) of RHA is generate [11].

MATERIALS AND METHODS

The rice husk used in this work was collected from rice paddy industry in Ikole Ekiti, Ekiti State, Nigeria. Grinded rice husk (GRH) was obtained by milling rice husk inside milling machine (Figure 1).

Figure 1. Showing rice husk being milled to produce GRH

Rice husk is burnt approximately 48 hours under controlled combustion process inside ferrous-cement furnace to produce rice husk ash (RHA). The burning temperature was within the range of 600°C to 850°C (Figure 2). The ash obtained is ground in a ball mill for 30 minutes and its color was seen as grey

Figure 2. Showing RHA being produce inside ferrous-cement furnace

Table 1. Quantities of Materials per Cubic meter of Concrete for various Batch

Mix No	Percentage Replacement (%)	Cement (kg)	GRH (kg)	RHA (kg)	Fine Aggregate (kg)	Coarse Aggregate (kg)	Water-Cement Ratio
1	0%	14.46	-	-	25.31	33.11	0.45
2	5% GRH	13.74	0.73	-	25.31	33.11	0.45
3	10% GRH	13.01	1.45	-	25.31	33.11	0.45
4	5% RHA	13.74	-	0.73	25.31	33.11	0.45
5	10% RHA	13.01	-	1.45	25.31	33.11	0.45
6	20% RHA	11.56	-	2.90	25.31	33.11	0.45

MIX PROPORTIONS

The concrete mix design was done according to IS 456:2000 [17]. The traditional way of mix proportion in terms of fixed ratios of Cement: Fine Aggregate: Coarse Aggregate (in general by volume). Ordinary Portland Cement (OPC) was used for the standard concrete production of grade M40 (1: 1.75: 2.29). The cement content was partially replaced by GHA at 5% and 10%, and RHA at 5%, 10%, and 20%, in addition with control mix as shown in Table 1.

CASTING OF CONCRETE CUBES FOR CRUSHING

The concrete ingredients were thoroughly mixed and uniformly distributed within the concrete mass during various stages of handling. It was ensured that all the characteristics of concrete are in conformity with relevant codes of practice. The concrete was filled into the cube moulds of dimension 150 mm x 150 mm x 150 mm in layers of 50 mm thick. Each layer was compacted with not less than 35 strokes per layer using a tamping rod so as to avoid any voids.

The top surface was leveled and smoothened with a trowel. The specimens were marked for identification and stored in moist air for 24 hours and later removed from the moulds. Compressive strength test was performed after curing the samples for 7 days, 14 days and 28 days using compression testing machine (Figure 3).

Figure 3. The compression testing machine

The specimens were aligned centrally on the base plate of the machine and the movable portion of the machine was rotated gently by hand so that it touches the top surface of the specimen. Load was applied gradually without shock and continuously at the rate of 140kg/cm^2/minute till the specimen fails. The maximum load was recorded and any unusual features in the type of failure were noted.

RESULTS AND DISCUSSIONS

The results of the compressive strength obtained for M40 grade of concrete were shown in Table 2. It showed that as the age advances, the compressive strength and weight of concrete cubes increases.

The target mean compressive strength (f_t) expected at 28 days is given by equation 1;

$$f_t = f_{ck} + 1.65\,S \qquad (1)$$

where f_{ck} = 40 N/mm^2 and

S = standard deviation for each grade of concrete, taken as 5.0 for grade M40 obtained IS 456:2000

From equation 1, expected target compressive strength of concrete is given as;

$$f_t = 40 + 1.65 \times 5 = 48.25\ N/mm^2$$

The percentage change in compressive strength was less than 18% for all the partially replaced GRH and RHA in relation to the control mix. The control mix at 28 days had the highest weight of concrete cube at 84.07N and the lowest weight was 20% RHA partial replacement at 7 days having a weight of 67.00N.

The compressive strengths for 5% RHA partial replacement were more than the control mix at all age. At 10% RHA partial replacement, compressive strength was also higher than the control mix at 28 days. The maximum compressive strength recorded was 52.41 N/mm^2 for 5% RHA partial replacement, an increase of 6.81% over the control mix at 28 days.

The compressive strength of 5% GRH partial replacement was slightly decreased by 5.79% at 28 days, 9.25% at 14 days and 4.9% at 7 days. The minimum compressive strength results was 40.53 N/mm^2 at 28 days for 20% RHA partial replacement, a decreased of 17.40% compared with the control mix.

Table 2. Weight and Compressive Strength of Concrete Cubes at Grade M40

Replacement (%)	Weight (N)	Age (days)	Compressive Strength (N/mm^2)	Percentage Change in Compressive Strength (%)	Change Indicator
0%	78.48	7	40.44	-	-
0%	81.62	14	43.02	-	-
0%	84.07	28	49.07	-	-
5% GRH	75.84	7	38.45	4.9	Negative
5% GRH	77.23	14	39.04	9.25	Negative
5% GRH	79.79	28	46.23	5.79	Negative
10% GRH	68.47	7	35.87	11.30	Negative
10% GRH	69.62	14	37.91	11.88	Negative
10% GRH	73.87	28	45.47	7.34	Negative
5% RHA	79.62	7	42.88	6.03	Positive
5% RHA	81.83	14	49.78	15.71	Positive
5% RHA	84.20	28	52.41	6.81	Positive
10% RHA	71.62	7	38.09	5.81	Negative
10% RHA	75.83	14	42.58	1.02	Negative
10% RHA	77.20	28	50.24	2.38	Positive
20% RHA	67.00	7	33.24	17.80	Negative
20% RHA	69.51	14	35.42	17.67	Negative
20% RHA	71.96	28	40.53	17.40	Negative

COMPARISON OF COMPRESSIVE STRENGTH OF CONCRETE

Comparative results of the compressive strength obtained for the GRH partial replaced concrete and control mix were displayed in Figure 4, it indicated that at both 5% and 10% partial replaced GRH, the compressive strength were close to the results of the control mix as the coefficient of determination $R^2 = 0.9492$ and 0.9915 respectively.

Figure 5 showed that the compressive strength results of the partial replaced RHA were compared well with the control mix, at $R^2 = 0.7857$, 0.9938, and 1, for 5%, 10% and 20% RHA respectively, and also indicated that RHA partial replaced concrete at 20% can be predicted without error from the control mix at $R^2 = 1$.

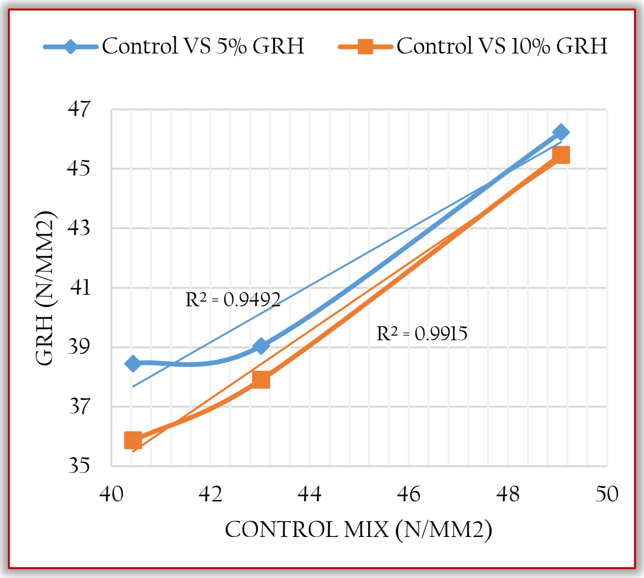

Figure 4. Comparative of Compressive strength (GRH vs. Control Mix)

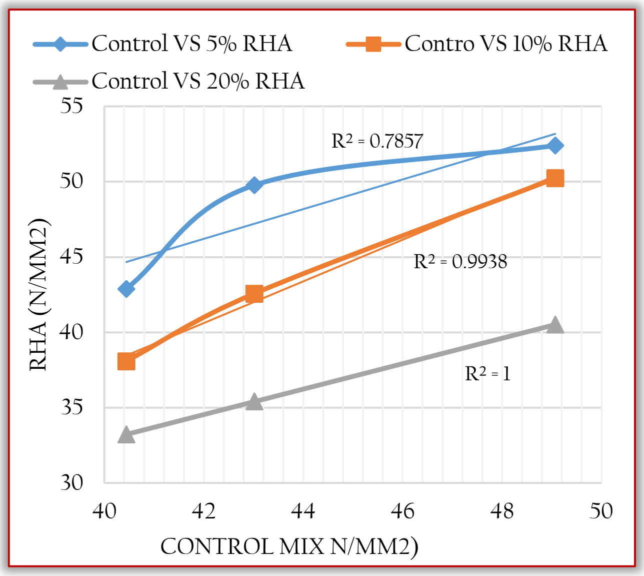

Figure 5. Comparative of Compressive Strength (RHA vs. Control Mix)

CONCLUSION

Based on experiments and test results on fresh and hardened concrete the it was established that addition of GRH at 5% and RHA at 5% and 10% partial replacement of cement made concrete becomes cohesive and more plastic and thus permits easier placing and finishing of concrete. It also increases workability of concrete. The target compressive strength attained at 28 days for 5% and 10% RHA concrete cubes were above the target characteristic compressive strength of 48.25 N/mm^2 for M40 grade. Replacement of cement at 5% RHA gave the optimum compressive strength of 52.41 N/mm^2 at 28 days age. The utilization of RHA and GRH hold promising prospects in the country because it softens the impact on the environment and capital cost of the structure.

References

[1] Neville A.M., *Properties of Concrete,* 4th Edition, Asia, Person Education Pte. Ltd. 2006.

[2] Udoeyo F.F., Sawdust Ash as Concrete Materials, Journal of Material in Civil Engineering, Vol. 14(2),pp. 173-176, 2002.

[3] Smith R.G. and Kamwanja G.A., Baghdad. The Use of Rice Husk for Making a Cementitious Material, Proc. Joint Symposium on the Use of Vegetable Plants and their Fibers as Building Material, 1986.

[4] Siddique R., Rice husk ash, In: Waste materials and by-products in concrete, Springer, pp.235-264, 2008.

[5] Anwar M., Miyagawa T., and Gaweesh M., 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, 2001.

[6] Tashima G.A., Brighter and brighter Picture of Agriculture. Vietnam Economy, 2005.

[7] Zhang M.H., and Mohan M.V., High-Performance Concrete Incorporating Rice Husk Ash as a Supplementary Cementing Material. ACI Materials Journal. Vol. 93(6): pp.629-636, 1996.

[8] Nicole P.H., Monteiro P.J.M., and Carasek, H., Effect of Silica Fume and Rice Husk Ash on Alkali-Silica Reaction. Materials Journal. Vol.97 (4): pp. 486-492, 2000.

[9] Sakr K., Effects of Silica Fume and Rice Husk Ash on the Properties of Heavy Weight Concrete. Journal of materials in civil engineering. Vol. 18 (3): pp.367-376, 2006..

[10] Sata V., Jaturapitakkul C., and Kiattikomol K., Influence of pozzolan from various by-product materials on mechanical properties of high-strength concrete. Construction and Building Materials. Vol. 21(7): pp.1589–1598, 2007.

[11] Mehta P.K., Pozzolanic and cementitious by-products as mineral admixtures for concrete - A critical review, ACI Special Publication Vol.79; pp.1-46, 1983.

[12] Bui D.D., Rice husk ash as a mineral admixture for High Performance Concrete, PhD Thesis, Delft University of Technology, Delft, 2001.

[13] Cook D., Rice husk ash cements: their development and applications, United Nations Industrial development organization, Vienna, 1984.

[14] Mehta P.K., Rice husk ash - a unique supplementary cementing material, Advances in Concrete Technology (2nd edition), pp.419-444. CANMET, V.M. Malhotra (eds), 1994.

[15] Mehta P. K., and Pirth, D., Use of rice husk ash to reduce temperature in high strength mass concrete. ACI Journal Proceedings, Vol.75: pp.60-63, 2000.

[16] Mehta P.K., High performance, high volume fly ash concrete for sustainable development. In: Proceedings of the International Workshop on Sustainable Development and Concrete Technology, University of California, Berkeley, USA, 2004.

[17] IS: 456. Indian Standard code book for RCC design guidelines, 4th Edition. Bureau of Indian Standards (BIS) New Delhi India, 2000

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