Proceedings of the Third International Conference on Engineering and Technology Research August 5 - 7, 2014 ISBN: 978-2902-58-6 Volume 3

COMPARATIVE STUDY OF THE EFFECT OF RICE HUSK ASH AND WASTE GLASS ON COMPRESSIVE STRENGTH AND WATER ABSORPTION RATIO OF CONCRETE COMPOSITES

Omobowale M.O*.,Gbadamosi A.S. and Ajisafe A.A.

Department of Agricultural and Environmental and Environmental Engineering
University of Ibadan,
Nigeria

*Corresponding Author: mo.omobowale@mail.ui.edu.ng

Abstract

The problem of disposing and managing solid waste in Nigeria where there is no visible regulations has become one of the major threats. With the recent ban on the importation of rice by Federal Government of Nigeria in order to boost local rice production, as well as the increase in volume of glass waste due to its use year-in-year-out in shops, construction sites and factories, wastes arising from these materials are expected to be on the increase. In order not to add to the environmental problems already being experienced in Nigeria, alternative and environmentally friendly uses must be found for these wastes. This study was conducted to determine and compare the compressive strength of concrete using rice husk burnt into ashes (RHA) and ground glass as replacement for fine aggregates at varying proportions for possible use in rural structures. Concrete mixture of 1:3:5 ratio (i.e. cement-sand-granite) was adopted for the study. While the proportion of cement and granite was kept constant, sand was gradually replaced with RHA and crushed glass in separate mixtures. Five replicates of each composite mixture were produced and tested in line with ASTM standard C67-07a after 28 days of water curing. Findings reveal that composites having about 66.7% to 100% of glass replacement gave better compressive strength than the control specimens with values ranging from 10.6N/mm^2 to 12.2N/mm^2 compared with a mean value of 9.6N/mm^2 obtained from testing the control specimens. However, composites having about 16.7% of RHA replacement had compressive strength greater than the control with 11.9N/mm^2. At total substitution of sand with RHA and glass wastes, water absorption ratiowas 47.5% and 10.9% respectively in RHA-concrete and glass-concrete composites compared with the control which was 9.1%. It was concluded that using both RHA and glass in concrete composite mixtures may be a viable option for rural structures in Nigeria and Africa at large in the nearest future while further work was recommended on the testing of other properties as well as the use of other solid waste materials and agricultural residues.

Keywords: Rice Husk Ash, Glass, Concrete, Compressive Strength, Water Absorption Ratio

1.0 Introduction

The construction industry is one of the fastest growing sectors in the world and as rapid construction activities continue, there is growing demand for various structural materials. The demand for high quality building materials to replace the conventional ones as well as the need for cost effective and durable materials for low cost structures have necessitated the development of a variety of new and innovative building materials (Mijinyawa, 2010). The problem of disposing and managing solid wastes in Nigeria, where regulations are not adhered to, has become a major environmental risk. Arising from this, the use of residues from waste materials in construction has been the subject of many research efforts due to environmental concerns within the last decade, (Mauro et al, 2009).

The use of certain components with potentially pozzolanic reactivity can significantly improve the properties of concrete. One of such materials among agricultural waste is rice husk ash (Ramezanianpour et al, 2009). Moreover, glass, being one of the widely used materials worldwide is also known for its pozzolanicproperties.

Rice husk is the hard, protective shell on the grain and its removal is the first stage of rice milling (RAA, 2007). Rice husk is the main by-product of rice production and for every tonne of paddy rice harvested, about 20% of rice husk is produced. Of all the staple crops, rice has risen to a position of preeminence (Akande, 2001). Since the mid-1970s, rice consumption in Nigeria has risen tremendously, at about 10% per annum due to changing consumer preferences (Akande, 2001). Domestic production has so far not been able to meet local demand, leading to considerable imports (Akande, 2001). The Federal Government of Nigeria in 2011 launched an agricultural programme in a bid to diversify economy and improve on agricultural production, the focus of which is to lower the cost of food and accelerate food production to meet local needs (Ibrahim et al., 2011). This agricultural improvement programme includes the launch for rice production revolution, earmarking 650 000 hectares of land for cultivation of the crop and targeting about 500 000 metric tons of rice annually, to render the country self-sufficient in rice production within four years (Ibrahim et al., 2011).

In Nigeria, the projected paddy rice harvest is estimated at 500,000 tonnes per annum (Ibrahim et al., 2011). Considering the plan to ban the importation of rice as well as the current drive of Federal Government of Nigeria to boost local production to levels at which the country will be self-sufficient in rice production, wastes arising from processing operations on rice is expected to be on the increase. In view of the fact that 20% of raw rice is made up of the husk, approximately 100,000 tonnes of additional waste is expected and this is likely to be on the increase every year until Nigeria is self-sufficient.

Glass on the other hand is a man-made material that is widely used in many industrial applications. It is an amorphous (non-crystalline) solid material, typically brittle, and can withstand the effects of wind, rain, and sun (Wikipedia, 2012). It is widely established that glass waste is of large volume and is increasing yearly in the shops, construction areas, factories and dumpsites (Topcu and Canbaz, 2004).

Glass waste disposal forinstance is becoming a serious environmental concern especially for a country like Nigeria where waste disposal is one of the important aspects of urban management crises and this has led to its consideration for alternative uses (Akinola and Salami, 2001). For instance, (Mohamed and Asokan, 2009) reported that the use of Glass reinforced plastic (GRP) waste ground fibre, as replacement for fine aggregate in foamed concrete, increased strength with reduced weight. Moreover, the study revealed that the fire resistant properties of GRP filled foamed concrete were suitable for structural and semi-structural applications in lightweight partitions, wall and floor panels.

From these projections, there is need to consider environment-friendly use of these wastes other than dumpsite disposal as currently practiced. This study therefore considered the possibility of using rice husk ash (RHA) and glass waste aspartial replacement for sand in concrete composites by testing its compressive strength and water absorption ratio.

2.0 Materials and Methods

2.1 Materials:

The following materials were used in this study

i. **Fine aggregates:** This was made up of sand sieved with a 425 micron British Standard (BS) sieve. Soil particles passing through were used in producing the composites.
ii. **Coarse aggregates:**Thisconsisted of approximately two and a half inch gravel.
iii. **Portland cement and water**: Elephant Portland cement procured from a local store was used.
iv. **Rice husk:** Rice husk as shown in plate 1 wasobtained from a processing plant in the upland-rice growing community of Erin Oke, Osun State, Nigeria.
v. **Glass**: This was collected from waste disposal sites within the University of Ibadan and it was made up of broken louvers blades as shown plate 2.

Plate 1: Rice Husk

Plate 2: Glass waste

2.2 Methodology

Rice husk was burnt in an open furnace and the RHA obtained after 12 hours of combustion as shown in plate 3 was used. The glass wastes were thoroughly washed with water and detergent to remove dirt so as to avoid experimental errors after which they were air-dried (plate 4). The cleaned glass wastes were thereafter ground and sieved with a 425 micron BS sieve.

Plate 3: Rice Husk Ash Plate 4: Ground glass being sieved

Samples were moulded into 0.1 x 0.1 x 0.1m using a steel mould. To remove entrapped air, the moulds were vibrated intermittently. The trowel was used to scrape excess composite material while the top was smoothened with the hand trowel. Curing was done by sprinkling water over the samples regularly for 28 days.

2.2.1 Compressive strength: This test was performed in line with the recommendations of American Standard for Testing and Materials (ASTM) C67-07a. A total of 65 samples were produced based on concrete mixture 1:3:5 as shown plate 5. The following batching ratios were used:

i. 5 replicates of samples containing neither glass waste nor RHA (used as control)

ii. 30 samples consisting of 5 replicates at 6 different mixing ratios of glass waste as shown in table 1.

iii. 30 samples consisting of 5 replicates at 6 different mixing ratios of RHA, also shown in table 1.

Compressive strength was obtained by using the following formula:

$$\text{Compressive strength} = \frac{\text{Load at Failure (N)}}{\text{Surface area (mm}^2\text{)}}$$

Surface area of cube = 0.1m x 0.1m = 0.01m^2 = 10mm^2

Plate 5: Composite specimens for testing

Table 1: Mixing ratio for Compressive Strength Test

Cement	Sand	Glass/RHA	Granite	% of RHA/Glass to Sand
1	3	0	5	0
1	2.5	0.5	5	16.7
1	2	1	5	33.3
1	1.5	1.5	5	50
1	1	2	5	66.7
1	0.5	2.5	5	83.3
1	0	3	5	100

2.2.2 Water Absorption Ratio (WAR): This was tested on three mixing ratios as shown in table 2. Each sample was weighed and then immersed in fresh water at room temperature for 24 hours after which they were allowed to drain before being weighed again.

WAR was calculated based on the following relationship:

$$WAR = \frac{W2-W1}{W1} \times 100$$

W1 = Initial weight of specimen
W2 = Final weight of specimens

Table 2: Mixing ratio for WAR testing

Samples	% of RHA	Mixing Ratio-Cement:Sand/RHA/Glass	% Replacement of Sand by RHA/Glass
1	0	1:3.0:0.0	0
2	50	1:1.5:1.5	50
3	100	1:0.0:3.0	10

3.0 Results and Discussions

3.1 Compressive Strength (CS)

Table3 presents the results obtained from the test. Glass-concrete composite produced its highest CS at total replacement with sand while RHA-concrete had the highest CS at 16.7% after which strength reduced with increasing substitution of sand with RHA.Glass-concrete produced composites with better compressive strength than RHA-concrete. Moreover, the composite has the potentials of producing stronger materials than the control at certain proportions as shown in Figure 1.

Table 3: Compressive Strength of Glass-Concrete and RHA-Concrete Composites

Samples	Mixing Ratio: Cement:Sand/RHA/ Glass:Gravel	Percentage of RHA/Glass to sand (%)	Mean Compressive Strength with Glass as Replacement (N/mm2)	Mean Compressive Strength with RHA as Replacement (N/mm^2)
1	1:3:0:5	0	9.6	9.6
2	1:2.5:0.5:5	16.7	8.4	11.9
3	1:2:1:5	33.3	7.6	8.5
4	1:1.5:1.5:5	50.0	7.7	7.9
5	1:1:2:5	66.7	10.6	7.3
6	1:0.5:2.5:5	83.3	11	6.1
7	1:0:3:5	100.0	12.2	5.7

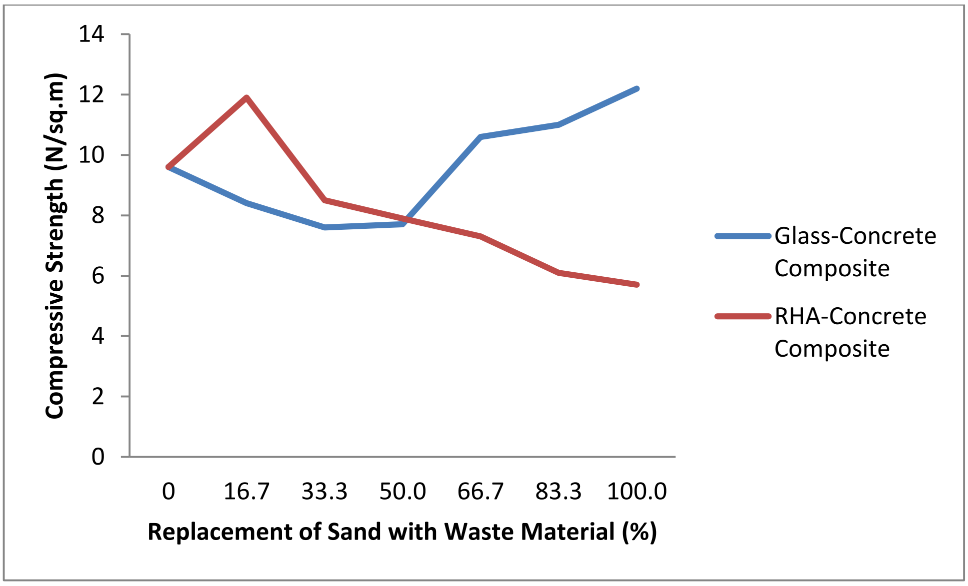

Figure 1: Average Compressive Strength of Glass and RHA Concrete Composites

3.2 Water Absorption Ratio: Table 4 presents the results obtained from the test. Water absorption was found to increase at all levels of partial replacement for both composites. However, the water absorption was found to be significantly higher in RHA-concrete composite as shown in Figure 2. Excessive WAR observed in RHA-concrete composite in undesirable in structural applications.

Table 4: Water Absorption Ratio of Glass-Concrete and RHA-Concrete Composites

Samples	Mixing Ratio: Cement:Sand/RHA/ Glass:Gravel	Percentage of RHA/Glass to sand (%)	Mean WAR of with Glass as Replacement (N/mm^2)	Mean Compressive Strength with RHA as Replacement (N/mm^2)
1	1:3.0:0.0	0	9.1	9.1
2	1:1.5:1.5	50	10.2	19.9
3	1:0.0:3.0	100	10.9	47.5

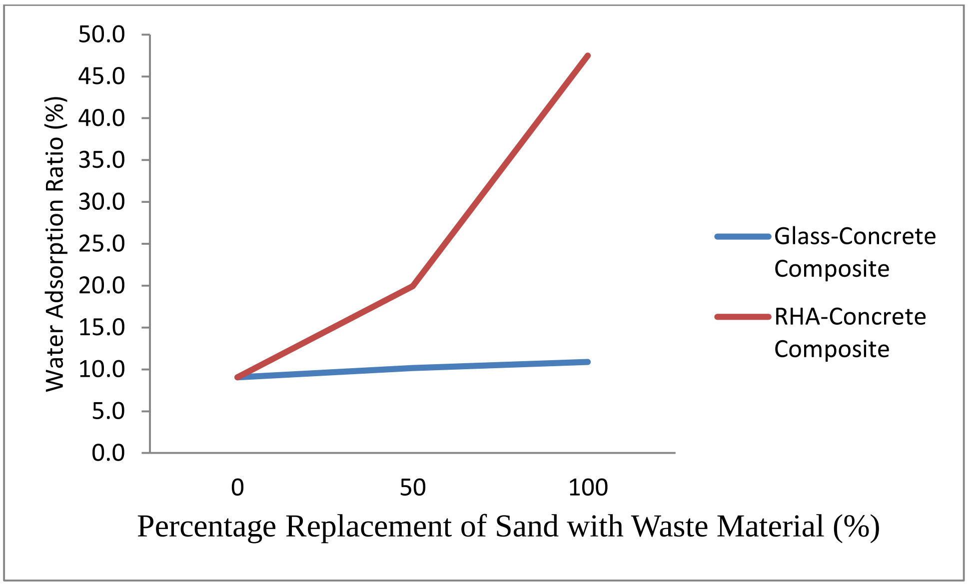

Figure 2: Water Absorption Ratio of Glass and RHA Composites

4.0 Conclusions and Recommendations

Waste materials from glass and rice husk were used in partial and total replacement of sand (fine aggregate) and it was concluded that these wastes can be used as constituents in concrete. While RHA was found be of beneficial advantage at about 16.7% replacement of sand, glass waste can be used in total replacement for sand in concrete mixture for structural purposes.

Arising from this study, the following recommendations are made:

1. Beneficial use can be made of glass and rice husk waste by incorporating them into concrete and this option should be considered be waste management authorities.
2. RHA-concrete composite are adequate for non-load bearing structural elements most especially where water use is minimal.
3. Glass-concrete composites should be adopted for use in both load and non-load bearing structural components of buildings
4. Further work should be done to investigate other engineering properties of these composites such as shear strength, tensile strength and bending strength.
5. Other industrial and agricultural waste materials such as plastics, kernels, wood shavings or a combination of these should be also be looked into.

References

Akande 'Tunji (2002). *An Overview of the Nigerian Rice Economy*. The Nigerian Institute of Social and Economic Research (NISER), Ibadan

Akinola.S. & Salami. R. (2001) "An Assessment of the Effectiveness Of Private Sector Participation Initiatives In Solid Waste Management In Mushin Local Government Area, Lagos State". Nigerian Journal of Social and Educational Research. A Publication of the Nigerian Association of Social And Educational Research, University Of Ado-Ekiti

Ibrahim A.Y., Ohai R., Yusuf O., Ojelade O. (2011). *Is Rice Revolution Possible in Nigeria*? the Nigerian Nation newspaper 20/11/2011: http://www.thenationonlineng.net/2011/index.php/business/26870-is-rice-revolution-possible-in-nigeria.html date accessed 15/12/2011

Mauro M. T., Carlos A. R., Jorge L. A., Michele B. B. (2008). *The Possibility of Adding the Rice Husk (RHA) to the Concrete.* Journal of Civil Engineering Department, FEIS/UNESP, Brazil

Mijinyawa Y. (2010): "Farm Structures"; University of Ibadan Publishing House, 2010, (ISBN: 978 – 978 – 8414 – 35 – 3).

Ramezanianpour A. A., Mahdi Khan M., Ahmadiabeni G (2009*). The Effect of Rice Husk Ash on Mechanical Properties and Durabilty of Sustainable Concretes.* International Journal of Civil Engineering

Ricegrowers' Association of Australia (RAA) (2007).*AboutRice:The Rice Growing and Production Process.*PO box 706 leetan NSW 2705 Austalia.www.aboutrice.com

Topcu I.B. and Canbaz M. (2004): "Properties of Concrete Containing Waste Glass," Cem. Concr. Res., Vol. 34, Pp. 267-274, February 2004

Wikipedia Encyclopaedia (2012): "Glass"; http://en.wikipedia.org/wiki/glass, Date Accessed: 05/01/2012