IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)
e-ISSN: 2278-1684,p-ISSN: 2320-334X, Volume 15, Issue 3 Ver. II (May. - June. 2018), PP 01-05
www.iosrjournals.org

Partial Replacement of Cement with Burnt Rice Husk Ash for Low Strength Concrete Production.

Ugwuanyi, S.E[1], Adibe, T.N[2], Mmonwuba, N. C[3]
1,2- Institute of management and Technology (IMT)- Enugu
3- chukwuemekaodumegwu ojukwu university uli anambra state.
Corresponding Author:Ugwuanyi, S.E

Abstract: *Nigeria, one of the leading African countries in economy makes use of sandcrete blocks and concrete for various types of structure in the construction industry. Thereby making cement expensive and unaffordable for many in the country. Rice Husk Ash (RHA) which is in abundance in the country can be substituted for cement in making sandcrete blocks and low strength concrete for construction. Investigations showed that inclusion of RHA in the production ofsandcrete blocks yields averagely and comparative strength with that 100% cement .Sorptivity and permeability were also observed to have increased with increase in RHA content. The highest compressive strength for concrete was attained at a percentage RHA content of 10 percent. Results also suggested that RHA as a substitute can act as an insulator in houses. If well optimized, RHA will serve as an alternative to OPC in the construction industry leading to the production of low density sandcrete blocks that cost less, concrete with a durable strength for construction of low income housing and also improve waste handling.*

Key Words: *Rice husk Ash, sandcrete block, agricultural waste*

Date of Submission: 05-05-2018 Date of acceptance: 21-05-2018

I. Introduction

Houses have become unaffordably high in cost for the vast majority of reasons in Nigeria relative to the economic status of the people. Reducing the amount of cement used in sandcrete and concrete production could go along way towards solving these problems, because sandcrete and concrete are important element of building in the sub urban and villages in Africa and especially in Nigeria which is the fastest urbanizing country on the African continent.

According to a report by Mr. AdamuMuhammed, the director of the federal ministry of Agriculture KanoState, rice production in Nigeria has hit 15 million tones as of 2017 with now about 34 states producing three times in a year. Rice husk is an agricultural residue gotten from the outer covering of rice grains during milling processlocally done by women using firewood as heat source and it is an excellent cement replacement when converted into ash due to its reactive silica and or alumina which when mixed with lime in the presence of water will set and harden like cement. (S.D. Nagrale, Dr. HemantHajare, Pankaj R. Modak, 2012).

Researches reported so far has indicated that rice husk ash is highly pozzolanic and very suitable for use in lime-pozzolona mixes and for Portland cement replacement (Smith, 1984, Chandrasekhar, 2003, Yogenda et al, 1988. Anwar 2000, Paya et al, 2000, Nair, 2006, Goncalves and Bergmann,2007, Rodrigues et al, 2008). Effect of RHA blended cement on strength and permeability properties of concrete has been investigated by Ganesan et al (2008) on sandcrete block, cisse and laquerbe (2000) observed that the mechanical resistance of sandcrete blocks obtained when unground ash was added increased in performance over the classic mortar block. Their studies on Senegalese RHA also revealed that the use of unground RHA enable production of light weight sandcrete block with insulating properties at a reduced cost. The ash pozzolanic reactivity was responsible for the enhanced strength obtained. Okpala (1993) partially substituted cement with rice husk ash in percentage range 30-60% at interval of 10% while considering the effect on some properties of the block. His results revealed that a sandcrete mix of 1:6 (cement/sand ratio) required up to 40% cement replacement and a mix of 1:8 ratio required up to 30% to be sufficient for sandcrete block production in Nigeria.

Exploiting agricultural waste material will not only maximize the use of the agricultural products but will also help preserve natural resource and maintain ecological balance (Teo et al, 2006) , will save energy, prevent pollution, enable subsequent economic sustainability and efficient recycling of solid wastes which is now a global concern.

In developing countries like Nigeria, proper utilization of Agricultural waste has not been given due attention. The rice husk thereby constitute an environmental nuisance as they are disposed as can be seen on some of our highway (AmasiriOkigwe)

Advancements in replacement of cement with RHA in sandcrete and low-strength concrete production will provide an economic use of by-products, reduce the rate of green house gases that cause pollution and consequently produce cheaper blocks with high strength and concrete that can be used as new construction materials.

II. Objectives

1. To reduce the weight and cost of sandcrete blocks
2. To economize the whole process of construction
3. To reduce cost of construction
4. To understand the compressive strength of concrete produced using rice husk ash.
5. To recycle rice husk which is an agro waste

III. Literature Review

Previous research effort shed light on using RHA as a building material. E. B. Oyetola and M. Abdullahi(2006), on their research on the use of rice husk ash in low-cost sandcrete block production concluded after they test on OPC/RHA hollow sandcrete blocks that rice husk ash produced using charcoal from firewood is pozzolanic and therefore is suitable for use in block making. They also noticed that for a given mix, the water requirement increases as the rice husk ash content increases including the setting time. Specific gravity, uncompacted bulk density and compacted bulk density of rice husk ash were found to be 2:1, 460 kg/m^3 and 530 kg/m^3 respectively and also the density of OPC/RHA is with the range for sandcrete block (500 to 2100 kg/m^3).

G.L. Oyekan and O.M. Kamiyo(2007), derived from the investigation on effect of Nigerian rice husk ash on some engineering properties of concrete and sandcrete block that the addition of RHA into the sandcement matrix produced sandcrete blocks of lighter weight and that a sandcrete block containing 10% RHA has the best heat resistant quality. The investigation also claimed that the maximum compressive strength of 29.35 N/mm^2 is obtained for the concrete cube specimen at a percentage RHA content of 5 percent and as the percentage increases the compressive strength decreases. For the 450mmx 150mm x 225mm blocks, the compressive strength increased at 5% RHA but began to decrease as the RHA percentage increased in the cement sand matrix.

Chukwudebelu, et al (2015), recommended on the paper on prospects of using while rice husk for the production of dense and hollow bricks that the use of RHA and lime to replace Portland cement and sand in production of bricks is an excellent alternative for developing countries like Nigeria. The production process for refined RH and marketing of blocks/bricks would provide employment within the rice growing area and also reduce carbondioxide emission in the air brought about bythe excessive burning of rice husk as well as provide clean environment devoid of heaps of rice husk.

They concluded that bricks made from rice husk could be cost effective especially in building houses for the lower income and vulnerable groups.

UsmanAliyuJalam et al (2016), in cost evaluation of utilizing building materials derived from Agricultural waste as sustainable materials for light weight construction concluded after the results that savings could be achieved by utilizing RHA obtained from RH as partial and complete replacement of the conventional building materials. An overall cost saving of about 24% in the total of material is possible if gotten from the environment it is generated. They recommended that rice processing mills could be designed to integrate a furnace in the production line which will allow ease and immediate processing of RH to RHA as the husk is being generated, or otherwise reduce the cost of transporting RH by compressing to about 500 kg/m3 without destroying its elasticity.

A study on the engineering properties of sandcrete blocks produced with RHS blended cement done by G.L Oyekan and O.M. Kamiyo(2011), observed that RHA does not appreciably enhance the compressive strength of the sandcrete block and could be attributed to the partial replacement of cement with RHA which cause a reduction in the quantity of cement in the mix available for the hydration process. Porosity increased at addition of 5% RHA which resulted in trapped air bubbles and will make such sancrete block absorb more liquid which will make it to fail fast when used in areas prone to flood or with year round rainfall like Niger Delta areas. Permeability and sorptivity increased which means that RHA opens up the block in a way that encourages upflow of fluid and would not be suitable for drainage channels construction but only for partitioning of building spaces. Other data obtained showed that density decreased with curing age.

S.P. Sangeetha(2016), concluded on his research on rice husk ash sandcrete block as low cost building material that rice husk which is a waste when used in making blocks will reduce quantity of waste in our environment. He also observed that the compressive strength of the blocks for all mix increases with age at curing and decreases as the RHA content increases. Due to the low cost of the materials, the manufacturing cost also decreased. Smita Singh and Mr. DilipKumari(2014),on alternate and low cost construction materials concluded that by using RHA in concrete as replacement, the emission of green house gases can be decreased to a greater extent and that RHA sandcrete block gradually increased in compressive strength from 0 days to 7 days and significant increased observed in strength from 7 days to 14 days which makes RHA a suitable material to be exploited by the construction company and rice industries.

Utilization of rice husk ash done by S.D. Nagrale et al (2012), Claimed that the use of RHA in concrete lead to around 8-12% saving in material cost and also helped in making an economical concrete. With addition of RHA, weight density of concrete reduced by 72-75% and can be used in light weight concrete for construction of structure where weight is of supreme importance. RHA can act as an admixture which will increase the strength, workability and pozzolanre properties of concrete.

IV. Material and Methods

Rice husk used were gotten from a milling factory at UzoUwani Enugu State, Nigeria. A locally fabricated furnace was employed. The husk are burnt into ash at a temperature below $483^{O}C$ and the RHA was seived to removed particles that do not pass the 45,mm text sieve (British standard institution 1997). While burning no addition of chemical to aid its burning and no grinding or special treatment to improve the quality of ash and enhance pozzolanicity.

Materials for production was cement, water, fine aggregates and coarse aggregate.

1. Fine Aggregate: Sharp River sand that is free of clay, loam, dirt and any organic or chemical matter.
2. Coarse Aggregate: Crushed granite of 20mm maximum size that is free from dirt, organic and chemical matter.
3. Cement: Cement used was ordinary Portland cement from West African Portland Cement Company, Ewekoro in Ogun State, Nigeria with properties conforming to BS 12 (British Standard Institution, 1971).
4. Water: Water is a vital ingredient in both block molding and concrete production as it actively participate in the chemical reaction with cement. Mixing water should not contain undesirable organic or inorganic constituent in excessive proportion. It should be fresh, colourless, odourless, tasteless and portable.
5. Grading of Aggregate: Grading has a considerable effect on the workability and stability of mix. It defines the properties of different sizes in the aggregate. Wet serving analysis which is an accordance with BS 1377 was used.

Production ofSandcrete Block

hollow blocks were produced with the standard mix proportion of 1:6 cement-sand ratio: that is one part by volume of cement to six parts by volume of fine aggregates. The size of blocks produced were 225 x 225 x 450mm hollow block.The quantities of materials obtained from the mix design were measured with the aid of weighing balance. The cement and RHA were mixed thoroughly over a number of times using hand mixing method until an even and homogenous mixture is obtained water was then sprayed on to the mixture using bucket and further turned over to secure adhesion with the aid of a shovel. Slump test was conducted to determine workability which was satisfactory. The resulting mortar was then rammed into moulds, compacted and smoothed off with a steel face tool.

The content were moulded and left in the concrete laboratory. The samples were kept wet during this period by watering or sprinkling water at least twice a day.

Manufacture of Concrete Cubes

The concrete cube specimen were made using approved cube moulds. A total of 12 cube specimens were made for each proportion of rice husk ash in the cement matrix for the compressive strength test. In order to remove trapped air in the concrete which could reduce strength of cubes, 150mm cube moulds were filled in 3 approximate equal layers and each were compacted using at least 35 tamps of the standard tamping bar before adding the next layer. After the top layer has been tamped, the top surface was trowelled with top of the mould.

Cubes were cured by immersion in water after the removal of moulds until the day for the testing when they were removed from the curing water tank and sun dried before being tested for strength. Universal testing machine was used and weight of each cube were recorded.

Permeability: It is the property of a porous medium which characterizes the ease with which a fluid will pass through under atmosphere pressure. Darcy's law states that the steady rate of flow is directly proportional to the hydraulic gradient. Thus can be expressed as

$$k = \frac{VH^2}{2th} \text{ foruni-axial penetration.}$$

Sorptivity: It is a measure of the capacity of a medium to absorb liquid by capillary action. Water resistance ability of blocks must be considered in order to minimize penetration of moisture or precipitated water into the interior of building.

The absorption of water under capillary action is directly proportional to the square root of time. (Hall, 1989).

$$A" = S\sqrt{t}$$

Thermal Properties: Thermal conductivity is a measure of the quantity of heat that flow through a material per unit time. Thermal properties of most cementations materials are found to change with the presence of admixture according to Cisse and Laqurebe, 2000 and Okpala, 1973.

V. Result and Discussion

The table below shows the compressive strength of sandcrete block.

Mix Ratio	Age at curing (days)	Average weight of blocks (kg)	Density (kg/m^3)	Failure Load (km)	Average failure load (km)	Compressive strength (N/mm^2)
100% OPC 0% RHA	3	21.4	2006.06	20.5,4,20	20.5	0.91
	7	20.32	1904.82	36,36,36	36	1.6
	14	20.8	1949.81	62,63,63	62.6	2.78
	28	21.08	1976.06	104,104,103	103.5	4.6
90% OPC 10% RHA	3	20.25	1898.25	16,16,15	15.8	0.7
	7	20.32	1904.82	29,30,30	29.7	1.31
	14	18.9	1771.7	54,55,55	54.7	2.43
	28	19.58	11835.45	92,92,92	92.0	4.09
80% OPC 20% RHA	3	19.14	1794.2	12,12,13	12,4	0.55
	7	19.18	1797.95	25,26,26	25.7	1.14
	14	18.39	1721.05	45,45.5,46	45.5	2.02
	28	19.28	1807.32	82,82,82,3	82.1	3.65
70% OPC 30% RHA	3	18.44	1728.58	8,8,8.3	8.1	0.36
	7	19.84	1859.82	16,17,17	16.7	0.74
	14	19.56	1833.57	30,31,30.3	30.4	1.35
	28	19.14	1794.2	46,47,46.6	46.6	2.07
60% OPC 40% RHA	3	19.28	1807.32	3,4,3.4	3.4	0.15
	7	19.84	1859.82	8,9,8.6	8.6	0.38
	14	19.04	1784.82	14,14.6,15	14.6	0.65
	28	18.94	1775.45	23,23.6, 24	23.6	1.05

Effects of RHA on Compressive Strength

The table shows that the block decreases in strength as the RHA percentage content in the design mix increases for lower percentage replacement level such as 10% RHA and 20% RHA, the silica for the pozzolana in the required amount and the hydration process produced sandcrete blocks with high compressive strength and the value obtained for the density of OPC/RHA sandcrete blocks fall within the range specified for sandcrete blocks (500-2100 kg/m^3).

Effects on Permeability

Increase in the percentage of RHA content increases permeability of the sancrete block and doubled with continuous increase in RHA content. this means that the continuous inclusion of RHA opens up the block wider in a way that aids up flow of fluid and indicates that the pore sizes becomes larger with increase in RHA percentage and will absorb and retain much water when exposed to persistent flooding.

Effect on Sorptivity

Sorptivity which is a measure of the capacity of block to absorb liquid by capillarity is observed and noticed that it gradually increased with percentage content of RHA and implies that the substitution of cement with Nigeria RHA forms a material structure that encourages liquid absorption.

Effect of Thermal Properties

Thermal conductivity increased with increase in percentage of RHA content and may be as a result of the productsof reaction of RHA with cement mix during hydration process. Except that there was a drop in the value for the 10 percent RHA content and these makes it the most suitable for building. This will reduce reliance on mechanical air-conditionary, extend period of human comfort during annual climatic cycle and also reduce size of air conditioning system required to cool or heat space.

Effect on Density

The table shows that density decreases with curing age and also varies with the percentage increase in the RHA content. This means that hollow sandcrete block produce with RHA have lighter weight.

Effect of RHA on Concrete

The highest compressive strength for the concrete cubes were attained at percentage RHA content of 10 percentage in the mix. As the percentage increased from 10% to 20% and 30%, the compressive strength of the cube decreased including density and average load failure.

Cost Evaluation

Cost saving is dependent on the distance of the agricultural waste from production site or construction site. An overall cost saving of about 24% in the total cost of material is possible. If the material are used within the immediate environ where the waste are being generated. 41% cost reduction in mass concrete is the highest cost saving thereby making RHA more economical (UsmanAliyuJalam, Abdurrahman Aliyu, Jalami, Ibrahim M. Sale 2016).

VI. Conclusion

From the analysis above it is important to infer that Sandcrete blocks produced with RHA at 10 percentage are lighter in weight and cost less when compared with OPC blocks. Although they be less resistant to impact as compared to 100%OPC the advantage abound.

RHA which is available in significant quantities as waste can be incorporated into block making thereby reducing waste in our environment. The compressive strength observed is durable for construction and also the production of sandcrete block at percentage of 10 has the best heat-resistant quality.

References

[1]. Anwar M, Miyagawa T, Gaweesh M (2000). Using rice husk ash as a cement replacement material in concrete.WastManage. Series, 1: 671-684.

[2]. Chukwudebelu, J.A., Igwe, C.C. and Madukasi, E. I. (2015). "Prospects of using Whole Rice Husk for the Production of Dense and Hollow bricks."African Journals of Environmental Science and Technology.Vol.9 issue 4,2018.

[3]. Cisse, I.K., Laguerbe, M (2000), Mechanical characterization of filler sandcretes with rice husk ash addition, study Applied to Senegal, Journal of Cement and Concrete research, Vol. 30, 2000.

[4]. Ganesan, K, Rajagopal, K. Thangavel, K. Selvaraji, R Sara Swarthi, V (2004). Rice husk ash – As versatile supplementary cementitious material.India Concrete Institute Journal 2004.

[5]. Nagrale, S.D.,Dr. Hemant H., Pankaj R. M. (2012). Utilization of Rise Husk Ash.International Journal of Engineering research and application. Vol.2,issue 4,2012.

[6]. Nair DG, Jagadish KS, Fraaij A (2006). Reactive pozzolanas from rice husk ash: An alternative to cement for rural housing. CemConcr. Res., 36(6): 1062-1071.

[7]. Okpala, D.C (1993). Some engineering properties of sandcrete blocks containing rice husk ash. Journal of building and environment Vol. 28, 1993

[8]. Onyekan, G.L. and Kamiyo, O.M. (2011). "A Study on the Engineering Properties of Sandcrete Blocks Produced with Rice Husk Ash Blended Cement." Journal of Engineering and Technology Research.vol.3,2011.

[9]. Oyetola, E. B. and Abdullahi M. (2006)."The Use of Rice Husk Ash in Low-Cost Sandcrete Block Production."Leonardo electronic Journal of Practices and Technologies.issue 8,2006.

[10]. Oyetola, E. B. and Abdullahi M. (2006)."The Use of Rice Husk Ash in Low-Cost Sandcrete Block Production."Leonardo ElectronJournal of Practices and Technologies. issue 8,2006.

[11]. Paya J, Monzo J, Borrachero MV, Peris-Mora E, Ordonez LM (2000). Studies on crystalline rice husk ashes and the activation of their pozzolanic properties. WastManage. Series, 1: 493-503.

[12]. Rodriguez de Sensale G, Ribeiro AB, Goncalves A (2008).Effects of RHA on autogenous shrinkage of Portland cement pastes.Cem.Concr.Compos., 30(10): 892-897.

[13]. Smita S. and Dilip, K. (2014). "Alternate and Low-Cost Construction Material: Rice Husk Ash." International Journal of Innovative research in advanced engineering.vol.1 issue 6,2014

[14]. Smith R (1984). Rice husk ash cement: progress in development and applications. Intermediate Technology Publications Ltd.

[15]. Usman A. S., Abdurrahman A. S., Ibrahim M. (2016). "Cost Evaluation of Utilizing Building Materials Derived from Agricultural Waste as Sustainable Materials for Light Weight Construction." Economic and Environmental Studies.Vol.16,2016.

[16]. Yogenda M.R. Jegadish, K.S, (1988), Pozzolanic properties of rice husk Ash, Burnt clay and red mud. Journal of building and environment Vol. 23, 1988.

Ugwuanyi, S.E "Partial Replacement of Cement with Burnt Rice Husk Ash for Low Strength Concrete Production." IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) , vol. 15, no. 3, 2018, pp. 01-05.