academicJournals

Vol. 9(5), pp. 493-501, May 2015
DOI: 10.5897/AJEST2013.1631
Article Number: ADDCEEF52472
ISSN 1996-0786
Copyright © 2015
Author(s) retain the copyright of this article
http://www.academicjournals.org/AJEST

African Journal of Environmental Science and Technology

Full Length Research Paper

Prospects of using whole rice husk for the production of dense and hollow bricks

Chukwudebelu, J. A.*, Igwe, C. C. and Madukasi, E. I.

Department of Chemical, Fibre and Environmental Technology, Federal Institute of Industrial Research Oshodi, Lagos Nigeria.

Receive 28 November, 2013; Accepted 25 March, 2015

One of the main reasons for the continued increase in the deficit of affordable housing in Nigeria is the high cost of brick made from sand and ordinary Portland cement (OPC). Finding a replacement for cement to assure sustainability is crucial as the raw materials used in making cements which are naturally occurring are depleting. Rice husk was milled and sieved to reduce the size to 0.020 mm. The moisture content of the rice husk was 9.98%, bulk density was 609.61g cm^{-3} and the ash content was 18.74%. Rice husk was wetted for 3, 6, 9, 12, 15 and 21 h and mixed with slaked lime at the ratios of 1:1, 3:1, 2:3 and 3:2. The composite was molded in cylindrical and rectangular mold using mechanical and hydraulic press. The compressive strength (CS) (N/mm^2) was tested at ages of 7, 14 and 21 days. The results show higher compressive strength in 1:1 as the bricks ages and also greater strength when wetted for 15 h. For 15 h wetting, 1:1 had CS (N/mm^2) of 2.59, 6.07 and 11.23. If well optimized, rice husk can be an excellent material for brick production thereby presenting a good alternative to OPC.

Key words: Hollow bricks, dense bricks, rice husk, compressive strength, molds.

INTRODUCTION

It is common knowledge that the demand for affordable housing grows at a faster pace than its supply in practically all countries of the world. Nigeria's housing deficit presents one of the very touching scenarios even within the context of developing countries (Basorun and Fadairo, 2012). According to Alitheia (2012), the national housing deficit rose from 7 million units in 1991 to between 12 and 15 million units in 2008; and currently stands at 17 million units (Adegboye, 2012). Unfortunately, there is indication that the deficit will continue to mount.

While the United Nations estimates that Nigeria's population would reach 289 million by 2050, the United States Census Bureau projects that the country's population will hit 264 million by 2050 (Nkah 2009). If so, Nigeria will then be the 8th most populous country in the world.

Rapid growth in population creates demand pressure towards shelter and efficient supply and distribution of basic utilities and services for the city dwellers. In most of Nigeria's urban centres, the problem of housing is not only restricted to quantity but also to the poor quality of

*Corresponding author. E-mail: adadebelu@yahoo.com.

Author(s) agree that this article remain permanently open access under the terms of the Creative Commons Attribution License 4.0 International License

Table 1. Projected cement and emitted CO_2.

2005 Production / Emission (M tonnes)						2050 Projected (BAU)	2050 Projected (BAP)
	USA	Canada	India	China	Global	Global	Global
Cement Produced	121	11.2	130	1064	2300	5500	5500
Total CO_2	109	10	117	958	2070	4950	4400

Source: International Energy Agency.

available housing units. The effect is manifested in overcrowding in houses. Nigeria is perhaps the fastest urbanizing country on the African continent. One of the most important challenges facing the country is the provision of affordable housing. As more and more Nigerians make towns and cities their homes, the resulting housing challenges need to be urgently addressed.

A study on the housing situation in Nigeria estimated that ₦12 trillion will be required to finance the deficit. In spite of a series of government policies towards housing delivery, one thing that is clear is there exists a gap between housing supply and demand (Nkah, 2009).

One of the main reasons for the continued increase in the deficit of affordable housing in Nigeria is the high cost of ordinary Portland cement (OPC), an essential constituent of concrete. Unfortunately, the increasing use of concrete in buildings is becoming problematic in developing countries because of the ever-rising cost of OPC (Arum et al., 2013).

Housing and sustainable development

Finding a replacement for cement to assure sustainability is crucial as the raw materials (limestone, sand, shale, clay, iron ore) used in making cements which are naturally occurring are depleting. The raw materials are directly or indirectly mined each year for cement manufacturing and it is time to look into the use of agriculture waste by-products in replacing cement (Kartini, 2011).

It is known that cement production is accompanied by the emission of huge amounts of CO_2, a greenhouse gas, into the atmosphere. It has been reported that approximately one ton of CO_2 is emitted into the atmosphere for every ton of cement produced, a fact responsible for about 7% of the total global production of CO_2 in 1995 (Karim et al., 2011). Moreover during cement production, clinker is burnt at a temperature as high as about 1450°C and this contributes to the environmentally negative phenomenon of global warming (Karim et al., 2011).

The growing demand for cement will outstrip all projected CO_2 emissions reductions plans. By 2050, cement demand is projected to be 5500 Mt/yr, an increase of 140% above 2005 consumption. Current and future cement and CO_2 emissions are shown in Table 1 with both Business As Usual (BAU) and Best Available Practice (BAP) scenarios. The International Energy Agency (IEA) estimates that maximizing efficiencies through best available practices and maintaining a 0.7 clinker factor would reduce CO_2 emissions to 0.8 tonnes per tonne of cement produced (Chirag et al., 2014).

The concept of utilizing excess biomass or waste from agricultural and agro-industrial residues to produce energy, feeds or foods, and other useful products is not necessarily new. The whole world thinks in the same path to overcome the pollution problems in environmentally sound methods using processes like composting, reuse, recycling, bioconversion, recovery, etc (Chukwudebelu et al., 2013).

Some amounts of investigations were made on the use of rice husk in construction particularly as lightweight and insulating filler in concrete. But it was not until the early 1970s when research emphasis was placed on the rice husk ash as a pozzolana. Brick is one accommodating unit as a building material due to its properties. From the previous research, attempts to incorporate waste in the production of brick were shown by many researchers for example limestone powder waste dust (LPW) and wood sawdust (WSW), (Turgut and Algin, 2006) process waste tea (PWT), (Demir, 2005), oil palm shell (OPS) (Mannan and Ganapathy, 2003) and kraft pulp (Demir, 2005). Ewais et al. (2014) synthesized wollastonite-based ceramics from cement kiln dust and rice husk ash through reactive crystallization sintering at lower temperature (1100-1200°C) compared to their synthesis from the pure constituents (>1400°C). They also utilized amorphous active RHA in place of crystalline quartz sand resulting in a reduction in the sintering temperature of the mixes of about 50 to 100°C

The additions of these waste materials have proven that the waste incorporation is not just environmentally advantageous but it also increases the performance of brick properties. However, the burning of rice husk to produce the ash used in these previous researches produce greenhouse gases that cause air pollution and will affect the people. The use of a whole rice husk in bricks production could be one of the alternatives to the burning process and the most cost effective way.

Table 2. Relative contribution of main rice ecologies to the rice sub-sector in Nigeria.

Production System	Major states covered	Estimated share of National rice Area (%)	Average yield (Ton/ha)	Share of rice production (%)
Rainfed Upland	Ogun, Ondo, Abia, Imo, Osun, Ekiti, Oyo, Edo, Delta, Niger, Kwara, Kogi, Sokoto, Kebbi, Kaduna, FCT and Benue States.	30	1.9	28
Rainfed Lowland	Adamawa, Ondo, Ebonyi, Ekiti, Delta, Edo, Rivers, Bayelsa, Cross River, Akwa Ibom, Lagos, all major river valleys, for example shallow swamps, of Niger basin, Kaduna basin, and inland of Abakaliki and Ogoja areas.	52	2.2	43
Irrigated	Adamawa, Niger, Sokoto, Kebbi, Borno, Benue, Kogi, Adamawa, Enugu, Ebonyi and Cross River, Kano, Lagos, Kwara, Akwa Ibom, Ogun State.	16	3.7	29
Mangrove swamp	Ondo, Delta, Edo, Rivers, Bayelsa, Cross River, Akwa Ibom, Lagos.	1	2.0	1

Adesina (2012).

Rice husks availability

Husk is obtained as a by-product of threshing paddy. In fact, about 20% of the dry mass of harvested paddy is husk. The husks, the main raw material for the production of rice husk brick are available at rice milling plants in rice growing areas.

Rice is an increasingly important crop in Nigeria. It is relatively easy to produce and is grown for sale and for home consumption. In some areas there is a long tradition of rice growing, but for many, rice has been considered a luxury food for special occasions only. With the increased availability of rice, it has become part of the everyday diet of many in Nigeria.

There are many varieties of rice grown in Nigeria. Some of these are considered 'traditional' varieties; others have been introduced within the last twenty years. Rice is grown in paddies or on upland fields, depending on the requirements of the particular variety; there is limited mangrove cultivation. New varieties are produced and disseminated by research institutes, or are imported from Asia. Rice is grown in all the States of the federation and F.C.T though production varies from state to state. Prevalent types of rice production systems in Nigeria include rainfed upland, rainfed lowland, irrigated lowland, deep water floating and mangrove swamp

The Nigerian government has embarked on an ambitious plan to make the country self-sufficient in rice production by 2015 under its current Agricultural Transformation Agenda, or ATA (Adesina, 2012). This initiative is in response to the perceived threat of larger volumes of milled rice imports into Nigeria since the 1990s, potentially displacing local production. Federal government of Nigeria brought in Dominion Farms, the largest American rice farm in Kenya. Today, they are investing $40 million on a 30,000 hectare area with the T.Y Danjuma Group in Taraba state. Also 50 young graduates from Taraba state have been sent to Kenya to be trained in commercial rice farming.

Federal government of Nigeria distributed previous year, 11,000 metric tonnes of high quality rice seeds before the flood and about 690,000 metric tonnes of rice paddy in the wet season have been harvested before the flood. With Rice Transformational Agenda (RTA) of the federal government a lot of improvements have been made in the rice sector. Table 2 shows relative rice contribution with respect to ecologies while Table 3 shows the expected incremental yield due to the effort of RTA.

To promote domestic production and displace imports, the Nigerian government has introduced a number of key policies and investment strategies. At the macro level, rice import tariffs are being increased to the point of a complete embargo by 2015, when the goal of rice self-sufficiency is supposed to be met (Johnson et al., 2013). The tariff increases are intended to protect the domestic rice sector while it undergoes improvements in paddy production, processing, and marketing with the support of public-sector reforms and investments. The reforms include deregulating seed and fertilizer markets and setting up private-sector marketing corporations to help

Table 3. Expected incremental average paddy yield (ton/ha) 2011 to 2015.

Registered farmers	2012	2013	2014	2015
Rainfed low land (paddy ton/ha)	3.5	4.5	5.5	6.0
Irrigated low land (paddy ton/ha)	4.0	5.0	6.0	7.0
Non Registered Rice farmers (paddy ton/ha	2.5	3.0	3.5	4.0

Adesina (2012).

coordinate the market and set grades and standards. Innovative financing mechanisms for supplying credit are also being pursued while physical investments are being made to establish staple crop processing zones (SCPZ) that are intended to encourage the clustering of food processing industries in proximity to raw materials and end markets (Johnson et al., 2013).

The rice mills are normally busier at harvest time, when they can mill to capacity. The quantity of paddy milled mainly depends on rice grown by small and large scale farmers. OLAM International Limited commenced rice production in Doma Local council of Nassarawa State in 2011, had invested $72 million into cultivation of 6000 hectares of irrigated and mechanized paddy to provide 36,000 metric tonnes of milled rice yearly for the domestic market.

Dangote Industries Limited (DIL) recently signed a memorandum of understanding (MOU) with the Federal Ministry of Agriculture and Rural Development (FMARD) investing $1billion (N165 billion) for the establishment of fully integrated rice production and processing operations across fives States in Nigeria. There are no records on the quantity of rice milled. In Nigeria, 3,000,000 tonnes of grains are produced annually. The amount of husks generated is 20% of 3,000,000 tonnes which is 600,000 tonnes.

At the time of the survey most of the husks generated in all these mills are disposed off either by: depositing in the open land and for burning; depositing on the river banks which will eventually be washed away; using for mulching; using for bedding in poultry and pig sheds.

The millers were not particularly concerned about the use of husks. Anybody wishing to collect the husks from the millers was free to do so and use them as they wish. Many researchers in Nigeria have done some work using rice husk in one form or the other, Opara (2006), Nicholas and Folorunsho (2012), Opeyemi and Makinde (2012) as well as Aderolu et al. (2007).

Mainly all these researchers used rice husk ash in their work and there is one reason or the other for the poor performance of the ash but there is room for improvement. Nevertheless though many uses had developed, observations during field survey revealed that husks continue to pile up at the milling sites, and the farmers had to clear the pile-up and take it to a dumping site for burning.

Social, economic and environmental benefits of using rice husk

Social

The bricks produced with rice husk will be lightweight and help to reduce the dead load in buildings. The use of light brick can also reduce transportation expenses and the cost of the walls. Besides, this kind of bricks can be used as thermal or noise insulator. It can also be used to design houses or social places like beaches, parks or eateries. Using rice husk for bricks will help in clearing it off the streets to improve the aesthetics of the surroundings.

Economic

For the farmer, agricultural residues can be a cash crop. Traditionally farmers have harvested grain and burnt or otherwise disposed of straw and other residues but the success of this research means that farmers can reap a "second harvest" from grain plantings.

In addition, because of the high cost of transporting agricultural residues to be processed into bricks, it is likely that industries will have to be built in rural areas, near the farms that supply the residues. This will boost local economies by providing jobs, services, and a higher tax base.

Environment

Cereal farmers annually burned the straw to prepare fields for future crops and control rice diseases. However, burning yields smoke and other pollutants which adversely affect air quality, visibility, human and environmental health. Industry advocates have said farmers need to burn the straw to protect crops from disease and because no alternative markets exist for the straw (Jon, 1997) Scientists have estimated that this resulted in the release of tons of carbon monoxide annually (Alex, 1995). Therefore at the end of this research farmers will also amass environmental dividends: studies have shown that the burning of

Table 3. Expected incremental average paddy yield (ton/ha) 2011 to 2015.

Registered farmers	2012	2013	2014	2015
Rainfed low land (paddy ton/ha)	3.5	4.5	5.5	6.0
Irrigated low land (paddy ton/ha)	4.0	5.0	6.0	7.0
Non Registered Rice farmers (paddy ton/ha	2.5	3.0	3.5	4.0

Adesina (2012).

Table 4. Properties of rice husk.

Parameter	Value	Literature
Moisture content	9.98 (%)	8.68 - 10.44
Ash content	18.74 (%)	8 - 20
Bulk density	609.61 (g cm^{-3})	270 - 650

agricultural wastes causes air pollution, soil erosion, and a decrease in soil biological activity, which eventually leads to soil crusting and may lower yields (Stephan, 1997; Paul, 1997). This is a renewable resource unlike materials for ordinary Portland cement.

MATERIALS AND METHODS

The rice husk used in this research was obtained from rice mill in Ifo, Ogun State Nigeria. The lime used was the recovered lime from welder's carbide sludge (Table 3 to 6).

Moisture content

Moisture content was determined using the oven drying method (ASTM, 2010). Aluminum dish was weighed using a digital balance (Model PM 4600, Mettler Instrument AG, Greifensee, Zurich). The rice husk sample was placed in the dish and the dish and sample were weighed. The dish and sample were then placed in an air-forced drying oven (Heratherm, Thermo Fisher Scientific Inc., Waltham, USA) and kept at 105°C until a constant weight was achieved. The dish containing the dried sample was cooled to the room temperature in a desiccator and then weighed. The moisture content was calculated on a wet basis as follows:

$$\text{Moisture content \%} = \frac{WW - DW}{WW} \times 100$$

Where, WW = the wet weight of the sample and dish (g); DW = the dry weight of the sample and dish (g).

Ash content

Empty crucible was cleaned and ignited in a muffle furnace at 525 ± 25°C for 30-60 min. It was then cooled slightly and placed in a desiccator, containing indicating-grade anhydrous alumina. At room temperature, the crucible was weighed on analytical balance and rice husk transferred to it. The crucible was place in a furnace at about 100°C and slowly raised to 525°C which carbonized the rice husk without flaming. At the end of combustion, the crucible was removed and cooled in a desiccator, then weighed. The process was repeated until constant weight was obtained:

$$\text{Ash \%} = \frac{A}{B} \times 100$$

Where, A= weight of ash (g); B= weight of rice husk (g)

Bulk density

An empty container (150 mL) was weighed using a digital balance (Model PM 4600, Mettler Instrument AG, Greifensee, Zurich)' The container was filled with rice husk and compacted to ensure absence of void spaces. The container and the sample were then weighed. Three replicates were carried out.

Bulk density (g cm^{-3}):

$$pb = \frac{(W_2 - W_1)}{V} \times 100$$

Where, pb= bulk density of the sample (g cm^{-3}), W_2= the weight of the container and the sample (g), W_1 = the weight of the container (g) and V = the volume of the container (cm^3).

Conditioning of the rice husk

The rice husk was screened to remove all debris and milled using 1mm and 0.027mm mesh sizes. Later 0.020 mesh size sieve was used to reduce the size of the rice husk.

Molding of bricks

The rice husk was wetted for 9, 12, 15 and 21 h. At the end of the

Table 5. Compressive strength of Ratio 1:1 (50% RH and 50% lime) for 14 days curing and 15 days wetting.

Height (mm)	Diameter (mm)	Force at peak (N)	Stress at peak (N/mm$^{2)}$	Energy to peak (N.m)	Force at break (N)	Stress at break (N/mm)^2	Energy to break (N.m)
13.570	30.00	4294	6.0739	7.5598	2457.1	3.4761	*12.307*

Table 6. Force/deflection table of the result.

Force at yield (N)	Stress at yield N/mm^2	Energy to yield (N.m)	Young Modulus N/mm^2	Def. at peak (mm)	Def. at break (mm)
4294	6.0748	7.7530	33.609	5.9790	7.2730

Table 7. Average compressive strength (CS) (N/mm^2) at Ratio 3:1 (75% rice husk and 25% lime).

Curing time (days)/wetting (h)	CS at3 h	CS at 6 h	CS at 9 h	CS at 12 h	CS at 15 h	CS at 21 h
7	1.01	0.34	0.99	4.93	2.94	1.59
14	2.58	0.44	1.96	5.73	3.19	2.18
21	3.33	2.09	1.30	5.19	10.44	2.37

Table 8. Average compressive strength (CS) (N/mm^2) at Ratio3:2 (60% rice husk and 40% lime).

Curing time (days)/wetting (h)	CS at 3 h	CS at 6 h	CS at 9 h	CS at 12 h	CS at 15 h	CS at 21 h
7	0.62	0.58	1.00	2.96	3.26	1.84
14	0.98	1.02	1.66	3.41	5.21	1.41
21	1.28	1.39	1.36	3.54	2.51	2.15

wetting period, it was mixed with lime recovered from carbide sludge at the ratios of 3:1, 1:1, 3:2 and 2:3. A mechanical and hydraulic press were used with wooden and iron mold to mold preliminary samples of cylinderical and rectangular bricks. Several samples were made and their compressive strength tested after 7, 14 and 21 days.

RESULTS AND DISCUSSION

The strength tests carried out was mechanical test to destruction for quality control. The sample is cylindrical and the mould was made of steel ASTM C 470 and conducted in accordance with ASTM C 31.

$$\text{Compressive strength (stress@ peak)} = \frac{\text{Force @ peak}}{\text{Area}}$$

$$\frac{\text{Force @ peak}}{\text{Piixr}^2} = \frac{4294}{3.142\text{x}15^2} = \frac{4294}{706.95} = 6.0739$$

From the graph, force at yield which is the same thing as force at peak can be determined. Also, stress at yield which is the same thing as stress at peak or compressive strength can be determined from the graph as well as deflection at peak (Figure 1).

The results of the tests on the compressive strengths of the rice husk/lime bricks are presented in the Tables 7 to 12. From all the results it was observed that the compressive strength of brick increased as the testing age increased. The highest CS was obtained with the ratio of 1:1 followed by 3:1 Also, it was discovered that 12 and 15 h wetting (damping in water) had higher CS. The 12 and 15 h wetting were then compared in Tables 7 and 8 and found out that the 15 h wetting had the highest value of compressive strength. When the strength of the brick from rice husk and lime was compared with the strength of mortar from OPC/RHA and lime/RHA in Table 13 it was discovered that it is not too far from the values of OPC/RHA but stronger than that of lime/ RHA. Though, this is preliminary study, it compares favourably

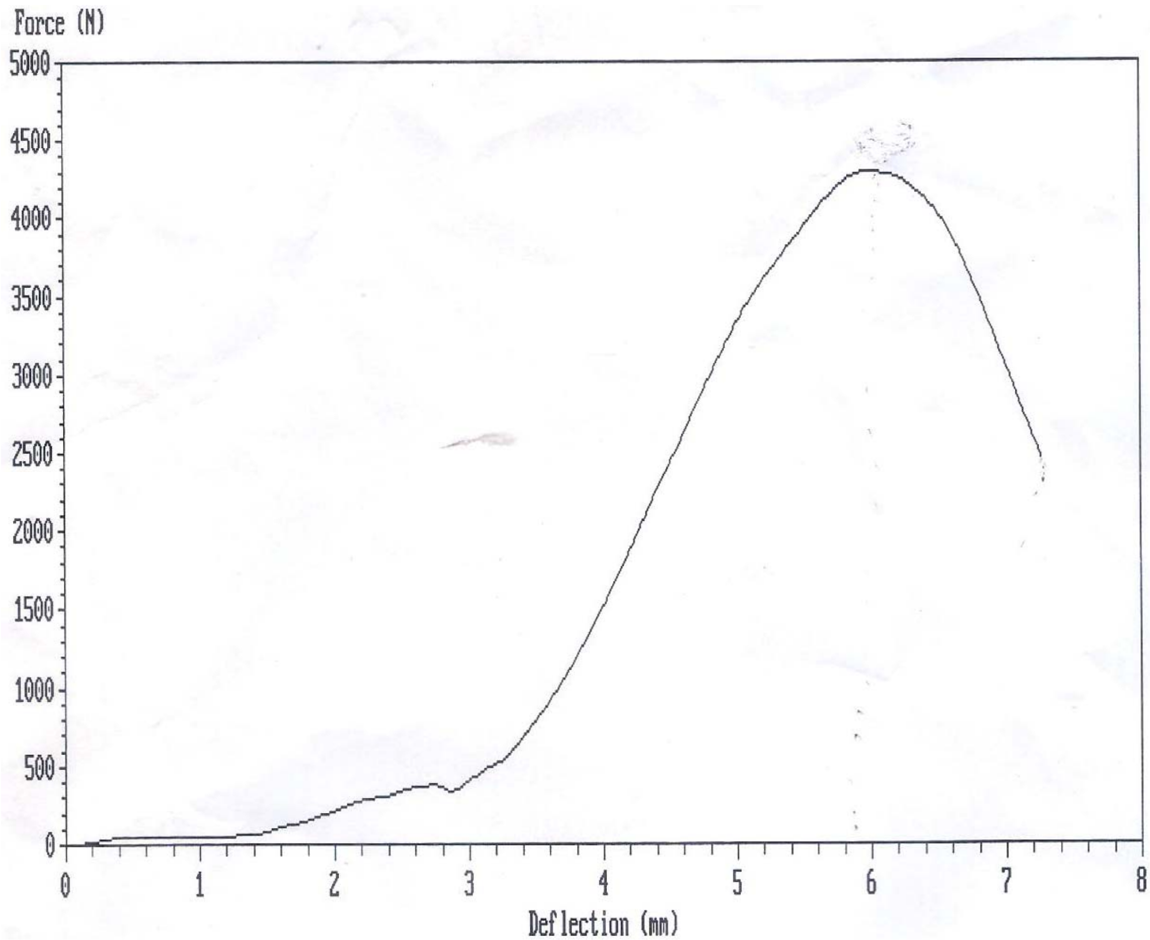

Figure 1. Force/deflection curve of the result.

Table 9. Average compressive strength (CS) (N/mm^2) at Ratio1:1 (50% rice husk and 50% lime)

Curing time(days)/wetting (h)	CS at 3 h	CS at 6 h	CS at 9 h	CS at 12 h	CS at 15 h	CS at 21 h
7	0.15	0.65	0.67	5.83	2.59	4.47
14	0.27	1.54	0.60	3.67	6.07	6.55
21	1.78	2.88		7.40	11.22	6.62

Table 10. Average compressive strength (CS) (N/mm^2) at Ratio 2:3 (40% rice husk and 60% lime).

Curing time(days)/wetting (h)	CS at 3 h	CS at 6 h	CS at 9 h		CS at 12 h	CS at 15 h	CS at 21 h
7		0.09	1.02	0.55	4.18	4.33	2.04
14		0.12	1.98	1.09	4.52	6.10	2.19
21		0.85	2.04	1.69	5.78	6.30	2.48

with the bricks from rice husk ash and that from OPC.

Adeyeye (2013), in his research on strength properties of commercially produced sandcrete blocks obtained 0.8 as the highest compressive strength. Also, Funsho et al.

Table 11. Average compressive strength (CS) based on 12 h wetting.

RH : Lime ratio/curing time(days)	7	14	21
1:1 (50:50)	3.67	5.83	7.40
3:1 (75:25)	4.93	5.20	5.73
3:2 (60:40)	2.96	3.41	3.54
2:3 (40:60)	4.18	4.52	5.78

Table 12. Average compressive strength based on 15 h.

RH : Lime ratio/curing time (days)	7	14	21
1:1 (50:50)	2.59	6.07	11.23
3:1 (75:25)	2.94	3.19	10.44
3:2 (60:40)	2.51	3.26	5.21
2:3 (40:60)	4.33	6.10	6.30

Table 13. Comparison of RH brick with mortar from OPC/RHA and Lime/RHA in 50:50 ratio.

Composition	7 days	14 days	21 days
Lime/ RH	3.67	5.83	7.40
	3days	**7days**	**28days**
Lime/RHA	1.4	2.3	2.8
OPC/RHA	5.9	8.6	10.3

Sabuni et.al, 2002.

(2013) used pulverized bone as as partial replacement of cement where they obtained 15.43 as the highest compressive strength after curing for 28 days. Demand of good quality building materials to replace the traditional materials and the need for cost effective and durable materials for the low cost housing has necessitated this research to develop variety of new and innovative building materials.

Construction materials of special requirements for the houses in different geographical region to overcome the risk of natural hazard and for protection from sever climatic conditions has also emphasized the need for development of lightweight, insulating, cost effective, durable and environment friendly building materials.

Conversion of waste into a commercially viable resource can be a path to relief to a financially depressed community. Recently, significant research has focused on improving both the economic and environmental sustainability of development. Engineered materials are manufactured commodities that may introduce financial gain and other opportunities into communities looking to develop sustainable economic growth (Baillie et al., 2011). By adding value to discarded waste material (such as by engineering agricultural waste-based composites), profits can be generated which, in turn, can provide financial wealth and a more stable economy for communities and countries (Gracia et al., 2010).

Even though using rice husk and lime to make brick has resulted to the decrease of compressive strength of the brick however the brick still compares well with bricks made from OPC and other composites.

Conclusions and recommendations

From the results obtained so far in this research it can be concluded that the use of RH and lime to replace Portland cement and sand in the production of brick is an excellent alternative for developing countries such as Nigeria. The preliminary investigation concentrated on the compressive strength therefore, further studies will be on other strength properties of brick which include setting time, soundness and fineness, slump, workability, density and standard consistence

The results of the study show that there are good prospects of using RH in combination with lime in the construction industry in Nigeria. The production process for refined RH and marketing of the bricks would also provide employment within the rice growing areas. It will help reduce the carbon dioxide emission in the air brought about by the excessive burning of rice husk as well provide clean environment devoid of heaps of rice husk.

Rice husk composite brick could be cost effective especially in building houses for the lower income and vulnerable groups. Greater emphasis should be put on Lime-rice husk brick since OPC is no longer within the reach of the poor in the Nigerian market.

Conflict of interest

The authors did not declare any conflict of interest.

REFERENCES

Adegboye K (2012). “52 Years of Homelessness: Experts Proffer Solutions to Dearth of Affordable Housing,” Vanguard Mobile Edition, www.vanguardngr.com.

Aderolu AZ, Iyayi E A, Onilude AA (2007). Changes in Nutritional Value of Rice Husk during Tricho derma viride Degradation. Bulgarian J. Agric. Sci. 13:583-589.

Adesina AA (2012). Unlocking the Potential of Agriculture in Sub-Saharan Africa: Nigeria’s Transformation Agenda for Agriculture. Abuja, Nigeria: Federal Ministry of Agriculture and Rural Development.

Adeyeye AO (2013). Strength Properties of Commercially produces Sandcrete Blocks in Ile Ife Nigeria. Int. J. Eng. Sci. Invent. 2(8):25.

Alex W (1995). "Straw: The Next Great Building Material" in Environmental Building News, 4(3):5.

Alitheia Capital (2012). “Housing-Creating the Right Envi- ronment. Lessons from other economies in tackling the housing crisis,” 24. www.thealitheia.com/newsletters, 20 March.

Arum C, Ikumapayi CM, Aralepo GO (2013). Ashes of biogenic wastes

—Pozzolanicity, prospects for use and effects on some engineering properties of concrete. Mater. Sci. Applicat. 4:521-527.
Baillie C, Matovic D, Thamae T, Vaja S (2011). Waste-based composites poverty reducing solutions to environmental problems. Resour. Conserv. Recycl. 55(11):973-978.
Basorun JO, Fadairo G (2012). “Government Challenges in Housing the Urban Poor in Ado-Ekiti, Nigeria,” J. Sust. Soc. 1(2) 31-35.
Chirag DM, Hirak SS, Jay JL, Darshan MM (2014). Compressive and Tensile Strength of Concrete Containing Rice-Husk Ash and Coir Fibers”. A.D.Patel Institute of Technology, Anand Gujarat Technological University, Ahmedabad.
Chukwudebelu JA, Igwe CC, Taiwo, OE, Tojola OB (2013). Recovery of pure slaked lime from carbide sludge: Case study of Lagos state, Nigeria. Afr. J. Environ. Sci. Technol. 7(6):490-495.
Demir I (2005). “An investigation on the production of construction brick with processed waste tea”, Building and Environment, 41, 1274-1278.
Ewais, Emad MM, Ahmed, Yasser MZ, El-Amir, Ahmed AM, El-Didamony, Hamdy. (2014). Cement kiln dust/rice husk ash as a low temperature route for wollastonite processing. Epitőanyag jsbcm, 66(3):69-80.
Federal Republic of Nigeria. (2006) Accelerated Rice Production in the Niger River Basin.TCP/NIR/3303 Main Report and Working Papers.
Funsho F, Efe I, Chris F (2013). Low-cost construction through the use of pulverizedbone foamed aerated concrete (PB-FAC). Civil Environ. Res. 3(10)107, www.iiste.org.
Garcia D, lopez,J, Balart R, Ruseckaite R, Stefani P (2010). Composites based on sintering rice husk waste tire, rubber mixtures. Mater. Design 28(7)2234-2238.
Jon M (1997). "Rice fields may burn in spring: Bill promises to help farmers, not hurt air," The Sacramento Bee.
Johnson M, Takeshima H, Gyimah-Brempong K (2013). Assessing the potential and policy alternatives for achieving rice competitiveness and growth in Nigeria. The International Food Policy Research Institute (IFPRI). Development strategy and Governance Division, IFPRI Discussion Paper 01301 November, 2013.
Karim MR, Zain MFM, Jamil M, Lai FC, Islam MN (2011). “Necessity and Opportunity of Sustainable Concrete from Malaysia’s Waste Materials,” Australian Journal of Basic and Applied Sciences, 5(5) 998-1006.
Kartini K (2011). Rice husk ash – pozzolanic material for sustainability. International Journal of Applied Science and Technology 1 (6) 169.
Mannan ,M. A. and Ganapathy, C. (2003), “Concrete from agricultural waste oil palm shell (OPS)”, Build. Environ. 39 (4) Elsevier.
Nicholas AM, Folorunsho OA (2012). Utilizing Rice Husk Briquettes in Firing Crucible Furnace for Low Temperature Melting Metals in Nigeria. ETASR - Engineering, Technol. Appl. Sci. 2(4)26-268
Nkah V (2009).The Economy Magazine Nigeria’s housing deficit: Balancing the equation.
Opara PN (2006). Usability of rice husk in the production of roofing sheets. J. Agric. Soc. Res. 6(1).
Opeyemi DA, Makinde OO (2012). The Suitability of Partial Replacement of Cement with Rice Husk Ash and Bone Powder in Concrete Structures. Inter. J. Emerging Technol. Adv. Eng. 2(9)261.
Paul R (1997). "Effect of Annual Burn No-Till Wheat on Soil Organic Matter Content and Bulk Density." Agricultural Research Service report number: 0000078618.
Sabuni WB, Syagga PM, Dulo SO, Kamau GN (2002). Rice Husk Ash Cement – An alternative pozzolana cement for Kenyan building Industry. J. Civil Eng. JKUAT 8:13-26.
Stephan A (1997). "Is burning an effective management practice for the pacific northwest cereal region?" Agricultural Research Service report number: 0000061281.
Turgut P, Algin HM (2006). Limestone dust and wood sawdust as brick material”. Build. Environ. 42:3399-3403.