



## **Production of Light Weight Blocks Using Rice Husk**

**C. U. Okpoechi<sup>1</sup>, C. A. Emma-Ochu<sup>1\*</sup>, L. C. Ibemere<sup>1</sup>, P. Ibe<sup>1</sup>, E. O. Onwuka<sup>2</sup>  
and A. C. Osuagwu<sup>2</sup>**

<sup>1</sup>*Department of Architecture, Federal Polytechnic Nekede Owerri, Nigeria.*

<sup>2</sup>*Department of Building Technology, Federal Polytechnic Nekede Owerri, Nigeria.*

### **Authors' contributions**

*This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.*

### **Article Information**

DOI: 10.9734/IJECC/2021/v11i930473

Editor(s):

(1) Dr. Wen-Cheng Liu, National United University, Taiwan.

Reviewers:

(1) Satya Prakash Mehra, Rajputana Society of Natural History, India.

(2) Md. Moniruzzaman, Bangladesh Reference Institute for Chemical Measurements (BRiCM), Bangladesh.

(3) Akinfiresoye Waleola Ayo, Federal Polytechnic, Nigeria.

Complete Peer review History: <https://www.sdiarticle4.com/review-history/75202>

**Short Research Article**

**Received 28 July 2021**

**Accepted 04 October 2021**

**Published 06 October 2021**

### **ABSTRACT**

Affordable housing has remained a major challenge in Nigeria, as housing costs have continued to rise beyond the reach of the low income population. This paper explores the use of waste products like rice husk as alternative materials for housing construction. Rice husk is abundant as a waste product in areas where rice is processed commercially in Southeast Nigeria. The aim of the study is to create rice husk blocks that are cheap, lightweight, and appropriate for use in low income housing construction. The study was conducted through experimentation in the Building Technology workshop of Federal Polytechnic Nekede. A series of trial mixes were done involving a wide range of materials and mix proportions. Rice husk, Portland cement, and cassava starch, were found to be the most appropriate components for the blocks. The blocks produced were of good appearance, and lightweight. Five samples of solid core blocks measuring 150x150x150mm were tested in Strength of Materials laboratory of the Federal University of Technology Owerri. The average compressive strength of the blocks was 0.26N/mm<sup>2</sup>, which is below the Nigerian Industrial Standard NIS 87:2007. The blocks produced were considered appropriate for use as non-load bearing partitions and not structural walls. The result of the study is promising because the rice husk blocks help address the waste management problem in affected areas, and could also be an important component of a potentially useful material. This paper recommends further research in the area of improving the strength of the blocks, to make them usable as structural components in low rise buildings.

\*Corresponding author: E-mail: [chidinmaeochu@gmail.com](mailto:chidinmaeochu@gmail.com);

*Keywords: Blocks; buildings; lightweight; rice husk; waste reduction.*

## 1. INTRODUCTION

Rice milling operations lead to generation of huge quantities of rice husk as waste. Rice husk is the outer shell of the rice grain which breaks to expose the rice, and makes up 20% to 22% of the weight of rice [1]. When it is separated from the grain, it becomes a waste material that is no longer required in further processing of rice. The chemical composition of rice husk varies depending on climate, geographical location, type of paddy, among other factors. On the average, it is composed of about 40% - 50% cellulose, 25% - 30% lignin, 15% - 20% silica, and 10% - 15% moisture content. Bulk density of rice husk falls within the range of 90 to 150kg [2,3].

In Nigeria, particularly South-eastern Nigeria which has rice producing communities like Abakiliki and Akaeze both in Ebonyi state, rice husk is often disposed of in open air heaps, and left for very long periods of time after which sometimes they are burned, also in open air. It is estimated that rice husk dumped as waste in Nigeria every year is appropriately 1.1 million metric tonnes [4], and generates millions of tonnes of carbon dioxide into the atmosphere from burning [5]. The rice husk disposed of in this way, causes air pollution, thus adding to the waste management problems of an already overwhelmed and inefficient system [6]. As a result, rice husk has become a threat to the environment [5,4], thereby calling for viable measures of turning such wastes to productive uses.

As part of waste recovery strategies, rice husk has been used in different productive applications. As an organic waste material, rice husk has found a variety of uses over time in different parts of the world. They have been used as an energy source, and pellets made from a mixture of rice husks and olive residues have been marketed [7]. Rice husk has also been used for electricity generation in off-grid rural locations, and for commercial and industrial uses [5]. As an insulating material, rice husk has been used as filling in walls and roofs for many years in China [8]. In building construction, studies have shown promise on the use of rice husk in development of composite materials. Rice husk ash has been used as part replacement for cement in concrete [9,10,11]. It has also been proposed as filler in the construction of bricks

[12]. The possibilities for the use of rice husk in other aspects of building construction can be further explored, following from already existing results.

As a component in building materials, rice husk has been used mostly as Rice Husk Ash (RHA). This involves burning the rice husk under controlled conditions to remove cellulose and lignin which are volatile organic matters in rice husk. The resulting residual ash is predominantly amorphous silica with a micro porous cellular structure [3]. The ash of rice husk contains about 90% silica, is highly porous, and has good insulating properties [3]. Good results have been recorded with this material, especially as part replacement for cement in concrete [13,9]. However, the use of rice husk in its raw state in manufacturing of material for building construction needs to be further explored, especially in low income communities where rice husk is dumped in large quantities as waste. Success in this area will eliminate the need for burning, which if uncontrolled, can greatly amplify air pollution in the affected communities. Controlled burning, which is the more commonly explored strategy has the likelihood of taking the resulting product out of the reach of the low income earners, as it would likely be done in properly set up industrial facilities. This approach will to some extent address the issue of indiscriminate dumping of rice husk as waste, but may put the resulting product out of the reach of intended beneficiaries.

This research is focused on two aspects of importance in Nigeria. First is waste management, and the second is housing affordability. The focus on waste management is to address the challenge of creating a clean and healthy environment, and reducing attendant hazards and degradation due to open air dumping and burning of wastes. The quest for housing affordability on the other hand is centered on exploring options in the use of alternative materials that can meet the functional requirements of conventional materials up to an acceptable standard, but at cheaper costs. Housing is a fundamental need in human societies, but its availability to the entire population has been limited due to a variety of factors, chief of which are socio-economic considerations. Affordability of housing especially where land is available, is largely dependent on cost of the materials and components required to

erect the house. In Nigeria, where sandcrete blocks are used extensively in building construction, any variation in cost of blocks will reflect on the overall cost of the building.

### 1.1 Aim and Objectives of the Research

This research into the use of a readily available waste material (rice husk) in the production of blocks, is aimed at producing relatively cheap and light weight blocks that can be used in low cost housing construction, with twin benefits of reduced cost and ease of placement due to its light weight.

The objectives of the research are:

1. To design and construct appropriate moulds for the production of lightweight composite blocks
2. To design appropriate mix for the lightweight blocks, with rice husk as the main component
3. To conduct tests to determine compressive strength and lightweight properties of the blocks produced
4. To determine the appropriateness of the developed material for use as a walling material.

## 2. MATERIALS AND METHODS

This study involved a determination of the suitability of rice husk as a component of blocks for building construction. The study was carried out in the concrete workshop of the Building Technology department of The Federal Polytechnic Nekede Owerri. The materials used were cement, rice husk, fine river sand, laterite, starch, and water. Different mix proportions were sampled in the bid to determine the most appropriate mix for making the blocks. These materials were used in different combinations and varying proportions for the different samples. Cement used was ordinary Portland cement (OPC) available in the local market. The cement was purchased in bags and transported to the study location. Rice husk was obtained from rice mills in Abakiliki in Ebonyi state. The material was collected in aerated sacks and transported to the workshop in Owerri where it was stored for use. Fine river sand with coarse texture was purchased from local dealers in Owerri. Usually silt content for this type of sand is between 5 to 20 %. Laterite was sourced locally also, and

collected in sacks and stored in the workshop. Starch was obtained from the open market in Benin in Edo state. The starch used was dried cassava starch extracted during commercial processing of garri, a staple food in the southern part of Nigeria. The cassava starch used, though a by-product of food processing, was also of food grade. Starch was used as an additive because of its remarkable characteristics, which include high paste viscosity. Clean potable water was used for mixing the samples.

Special block moulds were fabricated for the study. Initial moulds were made of steel, and designed to interlock. The material and design of the steel moulds were not compatible with the consistency of the block mixes and were discarded. Polished wood composite material (marine board) was then used for the moulds, with more satisfactory results. The moulds were fabricated to be detachable without applying pressure to the block. This was a precautionary measure to refrain from damaging the blocks during the de-moulding process. The final accepted moulds were for solid block fabrication only.

### 2.1 Mix Preparation

Several trial mixes were done in the course of the research, many of which were discarded for extremely poor outcomes. Mix proportions were varied until acceptable outcomes were achieved. Several trial mixes involving sand, cement, organic starch and water were made. Rice husk in its raw state was found not to bind well with cement. To achieve a better mix consistency, raw starch, being a by-product of garri processing was introduced as an additive. Inclusion of starch increased the setting time of the blocks, but improved cohesion of its constituent components.

A total of five (5) of the trial mixes are recorded in the study for further evaluation. Batching of materials was by weight. All materials were weighed dry before further processing. Water was used to mix the materials together. Hot water was used to process the starch, which was afterward cooled before use in the various mixes. The cement was first mixed with the starch solution until a smooth consistency was achieved. The rice husk was then poured into the mix, and water was added in controlled quantities until the desired workability was achieved.

All results included in the study are for solid blocks. The results are shown in Table 1 below.

### 3. RESULTS AND DISCUSSION

Tests for compressive strength were conducted in the Materials laboratory of the Federal University of Technology Owerri. A total of five (5) blocks were tested. One (1)

sample from mix **C** and four (4) samples from mix **E** were sent for tests. The blocks were made in trial cubes of 150x150x150(mm). The blocks were tested after 28 days. The test results are as shown in Table 2 below.

**Table 1. Experimental Mix Proportions**

S/N	Sample	Sand (laterite)/kg	Sand (river)/kg	Rice husk /kg	Starch /kg	Cement /kg	Observation (after 7 days)
1	A	-	5	10	-	10	The blocks appeared to be well formed, but were brittle after curing for 7 days. Laterite was suggested as an alternative to fine river sand to see if it would provide better binding properties.
2	B	5	-	5	-	12.5	The blocks were well formed. The blocks produced were quite heavy. Also the cement content was a lot and therefore not cost-effective. Starch was suggested as an alternative binder since the laterite appeared to increase the weight of the blocks.
3	C	-	-	1.5	0.5	2	The blocks were well formed, and not brittle. They appeared stable after 7 days. The blocks were considered good enough for further tests.
4	D	-	-	7.5	2.5	5	The starch was too much for this mix. This increased setting time of the block. Excessive evaporation of moisture caused shrinkage of blocks after curing
5	E	-	-	7.5	0.5	5	The starch was reduced in this sample. The blocks were well formed and appeared stable after curing. The blocks were considered good enough to undergo further testing.

**Table 2. Compressive strength of lightweight rice husk blocks**

S/No	Description	Sample E (i)	Sample E (ii)	Sample E (iii)	Sample E (iv)	Sample C
1	Dimensions (mm)	150x150x150	150x150x150	150x150x150	150x150x150	150x150x150
2	Weight (gm)	1.80	2.00	2.00	1.9	2.7
3	Density (gm/cc)	0.005	0.005	0.005	0.005	0.005
4	Cross sectional area (sq/mm)	$22.5 \times 10^{-3}$	$22.5 \times 10^{-3}$	$22.5 \times 10^{-3}$	$22.5 \times 10^{-3}$	$22.5 \times 10^{-3}$
5	Minimum load (KN)	0.50	0.50	0.50	0.50	5.8
6	Compressive strength (N/mm <sup>2</sup> )	0.0222	0.0222	0.0222	0.0222	0.2578

### 3.1 Discussion

The study was aimed at developing light weight blocks from rice husk, an organic waste material, for use in building construction. Rice husk was selected for the study because of its large scale availability in communities where rice is produced in commercial quantities. As a by-product of rice production, rice husk accumulates as waste, which is currently not effectively managed, seeing as it is dumped and oftentimes burned in the open.

The average compressive strength for sample E is  $0.02\text{N/mm}^2$ . This is substantially below the NIS 87:2007 standard [14], which specifies a compressive strength of  $2.7\text{N/mm}^2$  for  $150 \times 150 \times 450\text{mm}$  sandcrete blocks. Sample C has a compressive strength of  $0.26\text{N/mm}^2$ . While this is still below NIS 87:2007 standard [14], it compares with blocks sold in open markets in some parts of Nigeria, as shown in the study by Mahmoud, Hama, & Abba [15], where compressive strengths of  $150\text{mm}$  blocks were found to fall within the range of  $0.12\text{N/mm}^2$  to  $1.46\text{N/mm}^2$ . Sample C is preferred because of its better strength properties compared to sample E.

The final product was of good appearance and light-weight. With a compressive strength of  $0.26\text{N/mm}^2$ , it is not suitable for use as a structural wall. This effectively eliminates its use as a load bearing material in building construction. With a low compressive strength of  $0.26\text{N/mm}^2$ , the rice husk block samples are better suited for use as non-load bearing partition walls. A modified construction methodology of framing with wood and in-filling with rice husk blocks could still achieve the reduced construction costs. The finished block surface can readily receive cement/sand rendering, which would improve its moisture exclusion properties.

### 4. CONCLUSION

The waste reduction benefits of rice husk blocks are significant enough to elicit further enquiry into how rice husk blocks can be improved to serve as a structural material. This study explored the use of rice husk in its raw state, without turning it to rice husk ash. This was done to see how effective it would be as a primary material not requiring extensive processing, such as would make it more readily available to the lower income group. The compressive strength of the rice husk blocks produced was  $0.26\text{N/mm}^2$ . The result shows that the rice husk blocks produced are not suited for use as a load bearing material, but can be applied as partition walls and infills in framed construction. In addition, the light weight properties of the blocks can lead to increased productivity as a result of greater ease in handling the blocks. The finished block surface is also good enough to receive rendering and paint.

The emergence of rice husk blocks as a substitute for sandcrete blocks in building construction is quite promising. This is especially relevant in low rise housing construction, or as non-load bearing partitions in high rise construction. Rice husk block performs best as solid rather than hollow core blocks, and its composition gives it the benefits of improved fire properties and reduced weight which are also characteristics of hollow core sandcrete blocks.

### AREAS OF FURTHER RESEARCH

Further research is needed in the area of possible reduction of cement content of the blocks so that they are more cost effective and affordable to the low income population. In addition, further research is needed in the area of improving the compressive strength of the block, so as to make it more acceptable as a stand-

alone load bearing material, at least in low cost housing construction.

## CONSENT

As per international standard, respondents' written consent has been collected and preserved by the authors.

## ACKNOWLEDGEMENT

Funding for this research was provided by Tertiary Education Fund (TETFUND) Nigeria through the Federal Polytechnic Nekede Owerri Institutional Based Research Programme.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

## REFERENCES

1. International Rice Research Institute (IRRI) (n.d.). Commercial rice milling systems. Available:<https://www.knowledgebank.irri.org/step-by-step-production> 30th September 2021
2. Singh B. Rice husk ash. In R. Siddique, & P. Cachim, (Eds.), *Waste and Supplementary Cementitious Materials in Concrete: Characterization, Properties and Applications*. Woodhead publishing. 2018; 417-460. Available:<https://doi.org/10.1016/C2016-0-04037-8>
3. Phonphuak N, Chindaprasirt P. Types of waste properties and durability of pore-forming waste based fired masonry bricks. In F. Pacheco-Torgal, P. B. Lourenço, J. A. Labrincha, S. Kumar, & P. Chindaprasirt, (Eds.), *Eco-efficient Masonry Bricks and Blocks, Design Properties and Durability* Elsevier: Woodhead Publishing. 2015; 103-122.
4. Altine J, Ezekiel AM, Tanko B. Rice husk conversion for economic empowerment in Taraba state, Nigeria: A review. *International Journal of Trend in Research and Development*. 2017;4(5):515-519.
5. Ejiofor OS, Okoro PA, Ogbuefi UC, Nnabuike CV, Okedu KE. Off-grid electricity generation in Nigeria based on rice husk gasification technology. *Cleaner Engineering and Technology*. 2020;1:1-13. Available:<https://doi.org/10.1016/j.clet.2020.100009>
6. Chinedu I, Ezeibe C, Anijiofor SC. Solid waste management in Nigeria: Problems, prospects and policies. *Journal of Solid Waste Technology and Management*, 2018;44(2):163-172.
7. Nuamah A, Malmgren A, Riley G, Lester E. Biomass co-firing. *Comprehensive Renewable Energy*. 2012;5:55-73. Available:<https://doi.org/10.1016/B978-0-08-087872-0.00506-0>
8. Lin Ze-Zu. Reduction of energy consumption by enhancing thermal resistance of cold storage building. In S. W. Yuan (Ed.) *Energy, Resources and Environment Papers presented at the first US – China conference on energy Resources and environment*. November 1982, Beijing, China. 1982;7-12. Available:<https://doi.org/10.1016/C2013-0-03669-9>
9. Ettu LO, Njoku FC, Awodiji CTG, Amanze APC, Arimanwa MC. Variation of OPC-rice husk ash-saw dust ash composites strength with mix proportion. *International Journal of Engineering Sciences and Research Technology*. 2013;2(8):1964–1969.
10. Zerbino R, Giaccio G, Isaia GC. Concrete incorporating rice husk ash without processing. *Construction and Building Materials*. 2011;25 (1):371-378.
11. Srinivasreddy AB, Mc Carthy TJ, Luke E. Effect of rice husk ash on workability and strength of concrete. *Faculty of Engineering and Information Sciences – Papers: PART A*; 2004 . Available:<https://ro.how.edu.au/eispapers/2004>
12. Akinyele JO, Olateju OT, Oikelome OK. Rice husk as filler in the Production of bricks using Gboko clay. *Nigerian Journal of Technology (NIJOTECH)*. 2015;34(4): 672-678.
13. Zareei SA, Ameri F, Dorostkar F, Ahmadi M. Rice husk ash as a partial replacement of cement in high strength concrete containing micro silica: Evaluating durability and mechanical properties. *Case Studies in Construction Materials*. 2017; 7:73-81. Available:<https://doi.org/10.1016/j.cscm.2017.05.001>
14. Nigerian Industrial Standard. NIS 87:2007 Standard for sandcrete blocks. Standards Organisation of Nigeria, Lagos; 2008;

15. Mahmoud H, Hama HA, Abba HA. Compressive strength of marketed sandcrete blocks produced in Yola Nigeria. *Journal of Engineering and Applied Sciences*. 2010; 2:74-81.

---

© 2021 Okpoechi et al.; This is an Open Access article distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0>), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

*Peer-review history:*  
*The peer review history for this paper can be accessed here:*  
<https://www.sdiarticle4.com/review-history/75202>