COMPARATIVE PERFORMANCES OF BLOCKS PRODUCED FROM PARTIAL REPLACEMENT OF FINE AGGREGATE WITH SAWDUST AND RICE HUSK

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Abstract

Sand was partially replaced with prepared sawdust and rice husk respectively to produce light weight blocks. The rice husks and sawdust were used to replace sand in the order of 5, 10, 15, 20, 25, 30 %. A total of 156 blocks were produced, cured and tested for compressive strength, water absorption and bulk density. For the respective replacement materials, the compressive strengths decreased with increase in percentage replacement but increased with increase in curing age. The maximum strength for replacement with sawdust was 1.77 N/mm^2 at 5% replacement and curing age of 28 days; while the minimum strength was 0.33 N/mm^2 and was recorded at 30% replacement and curing age of 7 days. A maximum strength of 0.79 N/mm^2 at 5% replacement with rice husk and curing age of 28 days was recorded; while the minimum strength was 0.30 N/mm^2 and was recorded at 30% replacement and curing age of 7 days. Only the blocks produced from replacement with sawdust at 5% replacement and 28 days curing age had strength value greater than 1.75 N/mm^2 stipulated in Federal Building Code. Blocks produced from partial replacement with sawdust were of higher strengths compared with the blocks from partial replacement with rice husks. The water absorption capabilities of the blocks grew with increase in percentage replacement with sawdust and rice husks respectively. The water absorption capabilities of blocks produced from replacement with rice husks were higher than those of blocks produce from replacement with sawdust. For replacement with both materials, the highest water absorption capacities were recorded at 30% replacement, the lowest value occurred at 5% replacements. For replacement with rice husk, only blocks produced at 5% replacement had water absorption capacity (11.34%) < 12% (minimum) provided in Federal Building Code. In the case of replacement with sawdust, blocks produced at 5% and 10% replacements had water absorption capacities 10.50% and 11.44% respectively less than 12% set as minimum in the Federal Building Code. There was decrease in bulk densities of all blocks with respect to percentage replacement of sawdust and rice husks respectively. For replacement with sawdust and rice husk respectively, 61. 11% of the tested blocks were of bulk density values less than the minimum of 1500 Kg/m^3 specified in British Standard Institute. The blocks from partial replacement with sawdust were of higher bulk densities than the blocks from partial replacement with rice husks.

Keywords: Saw dust; Rice Husk; Blocks, Building Industry

Introduction

Sustainable development is a very important agenda in this century. This is where the world needs balance in maintaining resources, energy and resolving environmental problems (Subramani and Ravi, 2015). For example, the use of sand in the production of glass, electronics and concretes causing scarcity of sand is growing (Subramani and Ravi, 2015; Marcus, 2017). In addition to causing eco-system disturbance, the shortage of sand has turned sand from local product into expensive commodity. Therefore, in this study, sawdust and rice husk were used as partial replacement for sand in concrete production. The application of these materials will reduce the usage of sand which makes them more eco-friendly and economical than conventional concrete (Marcus, 2017). In Nigeria, rice husks are generally not used in construction. In order to make efficient use of locally available materials, this study was conducted to investigate and compare the influence of weight replacement and volume replacement of fine aggregate by rice husk on the workability, bulk density and compressive strength of block as well as to assess the suitability of rice husk block as a structural material.

The significance of sawdust and rice husk concrete production is to reduce the sawdust and rice husk waste that are produced which could save the environment for a long term run (Shafini et al., 2017). Another significance of this study is to reduce the amount of sand in the concrete mix which will eventually reduce the cost of construction.

The aggregate in sandcrete blocks contributes greatly to the self-weight of the concrete members in any concreting works. Therefore, their replacement with sawdust and rice husk from the abundant waste materials in the environment would reduce the self-weight of the blocks used in construction and to provide an environmentally friendly waste management strategy. This study is to partially replace fine aggregate (sand) with rice husk and sawdust respectively for the production of building blocks.

Material and Methods

Materials

Rice Husk: Rice Husk was sourced from Ekpoma in Edo State. The rice husks were made free from stones.

Sand: The clean, sharp river sand was used in the study. The sand was free from clay, loam, dirt and any organic or chemical matters. The sand passing through 3 mm zone of British Standard sieves as described in Sri Lanka Standard 855: 1989 was used.

Cement: The cement used in the study was Ordinary

Portland Cement (OPC)

Water: Fresh, colorless, odorless and tasteless potable water was used. Water was free from organic matters of any type.

Sawdust: Sawdust is a waste composed of fine particles of wood from different species and was sourced from sawmill in Oleh community. The sawdust was made free from large particles and stones.

Methods

Preparation of Cubes

The mold used were watertight and of the size of 100mm x 100mm x100mm and sealed on all sides to prevent leakage. The internal parts of the molds were greased to help prevent the sample from getting stuck to the molds when dried.

Batching was done by weighing, and the fine aggregate was substituted with sawdust and Rice Husk respectively in the order of 5%, 10%, 15%, 20%, 25% and 30%. Mixing was carried out manually; and 156 cubes (72 for replacement with sawdust, 72 for replacement with rice husks and 12 for control) were produced. Control samples (Pure sandcrete) were made of fine aggregate (Sand), cement and water with standard sandcrete mix ratio of 1:8:05.

The cubes were cured for 7, 14 and 28 days and were subjected to comprehensive strength, bulk density and water absorption tests respectively using equations (1) and (2).

Comprehensive strength test involved placing the sample to be tested on comprehensive strength testing machine and force was applied until the material failed. At failure, the strength was read in N/mm²

$$CS = \frac{AF}{A} \times 100 \qquad (1)$$

Where CS is comprehensive strength, AF is applied force at which the cube failed, and A is cross- sectional area.

Water absorption is decrease in mass divided mass of dry sample. After taking the weight of cubes at day 28, the cubes were wholly immersed in water and brought out of the water. Water on the surface of the cubes were wiped with the piece of cloth before weighing again. The mass of each cube before curing were minus from the mass obtained after curing to arrive at the volume of water absorbed by cube and expressed in percentage (water absorption).

$$WA = \frac{M1-M2}{M1} \times 100 \qquad (2)$$

Where WA is water absorption, M1 is dry mass and M2 is wet mass

The performances of all cubes were compared with compressive strength and water absorption capacity provided in Federal Building Code (2006), while the bulk density was compared with the minimum provision of the British Standard Institute (2002).

Results and Discussion

Compressive Strength

The compressive strength results for partial replacement of sand with sawdust are shown in Figure 1. The compressive strengths of blocks decreased with percentage replacement of sand with sawdust but increased with curing age. The maximum strength was recorded as 1.77 N/mm^2 at 5% replacement and curing age of 28 days. The minimum strength was recorded as 0.33 N/mm^2 and was recorded at 30% replacement and curing age of 7 days. For all the curing ages, the maximum strengths were recorded at 5% replacement, and the minimum strengths were recorded at 30% replacement. The maximum strengths recorded at the different curing ages and at 5% were 0.57, 1.62 and 1.77 N/mm^2. The minimum strengths recorded at the different curing ages and at 30% replacements were 0.33, 0.44 and 0.44 N/mm^2. The maximum strength in this study is higher than the maximum strength (0.54 N/mm^2) recorded for cubes produced from partial replacement of sand with rice husks in (Atikpo et al., 2019); but less than 1.78 N/mm^2 recoded for cubes from partial replacement of sand with used papers in (Atikpo et al., 2018).

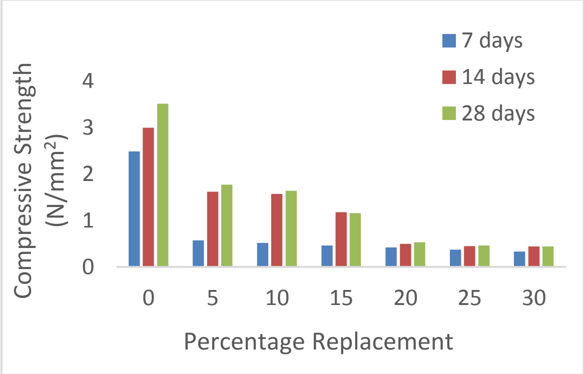

Figure 1: Compressive strength from replacement with saw-dust

The compressive strength results for partial replacement of sand with rice husk are shown in Figure 2. The compressive strengths of blocks decreased with percentage replacement of sand with rice husk but increased with curing age just like the observations for replacement with sawdust. The maximum strength was recorded as 0.79 N/mm^2 at 5% replacement and curing age of 28 days. The minimum strength was recorded as 0.30 N/mm^2 and was recorded at 30% replacement and curing age of 7 days. For all the curing age, the maximum strengths were recorded at 5% replacement, and the minimum strengths were recorded at 30% replacement like in the case of replacement with sawdust. The maximum strengths recorded at the different curing ages and at 5% were 0.54, 0.62 and 0.79 N/mm^2. The minimum strengths recorded at the different curing ages and at 30% replacements were 0.30, 0.40 and 0.43 N/mm^2. The maximum strength in this study is higher than the maximum strength (0.54 N/mm^2) recorded for cubes produced from partial replacement of sand with rice husks in (Atikpo et al., 2019); but less than 1.78 N/mm^2 recoded for cubes from partial replacement of sand with used papers in (Atikpo *et al.*, 2018).

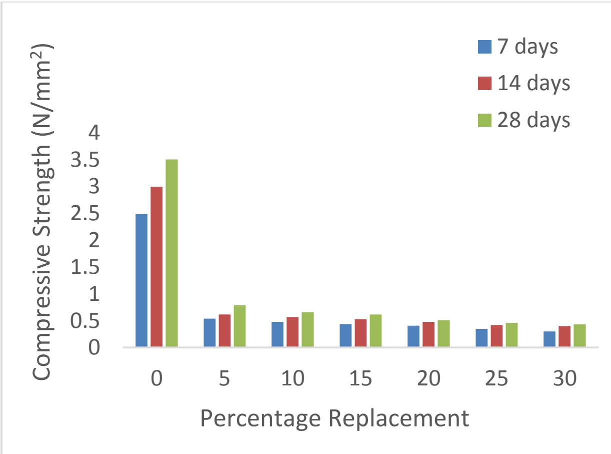

Figure 2: Compressive strength from replacement with Rice Husk

On evaluation of the performances of the blocks produced from the different replacements with both materials, the strengths of the tested blocks were compared with a minimum standard (1.75 N/mm^2) provided in Federal Building Code (2006). Only the blocks produced from replacement with sawdust at 5% replacement and 28 days curing age were of acceptable standard because the strength of the tested block at this replacement was greater than 1.75 N/mm^2 stipulated in Federal Building Code (2006). None of the blocks produce from partial replacement with rice husk had strength equal in value to the 1.75 N/mm^2 stated in the Federal Building Code (2006). Comparison of blocks from partial replacement with sawdust and partial replacement with rice husks revealed that the blocks produced from partial replacement with sawdust were of higher strengths compared with the blocks from partial replacement with rice husks. This is graphically displayed in Figure 3.

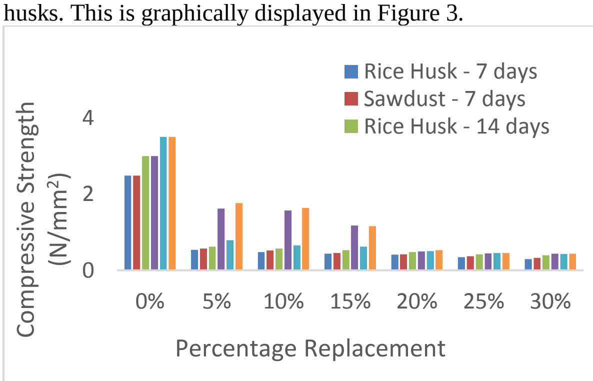

Figure 1: Compressive strength for both replacement

Water Absorption

Water absorption results for both replacements are shown in Figure 4. The water absorption capabilities of the blocks grew with increase in percentage replacement of sand with sawdust and rice husks respectively. The water absorption capabilities of blocks produced from replacement with rice husks were higher than those of blocks produce from replacement with sawdust. Water absorption capacity was reported by Subramani and Ravi (2015) to be inversely proportional to compressive strength. This is obvious in this study- blocks with rice husks had higher water absorption capacities but lower compressive strengths, while blocks with sawdust had lower water absorption capacities but higher compressive strengths. This is in line with findings of Subramani and Ravi (2015).

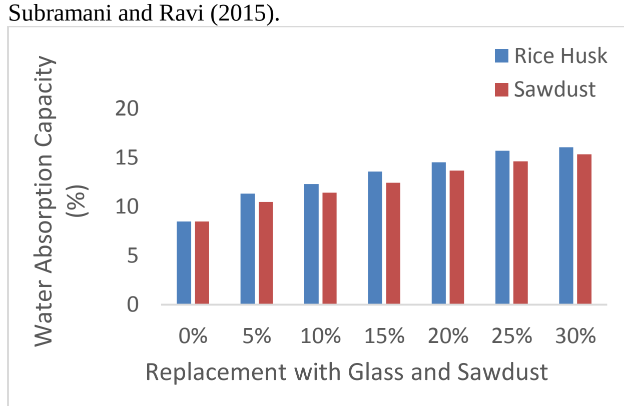

Figure 4: Water Absorption Capacity

For replacement with both materials, the highest water absorption capacities were recorded at 30% replacement, the lowest values occurred at 5% replacement.
When compared with the minimum standard water capacity (12%) set in Federal Building Code (2006), the blocks from both replacements generally performed poorly in terms of water absorption capacity. For replacement with rice husk, only blocks produced at 5% replacement had water absorption capacity (11.34%) < 12% provided in Federal Building Code (2006). In the case of replacement with sawdust, blocks produced at 5% and 10% replacements had water absorption capacities 10.50% and 11.44% respectively less than 12% set in the Federal Building Code (2006).

Bulk Densities of Blocks

The results of bulk densities of the tested blocks are presented in Figure 5 for replacement with sawdust, and presented in Figure 6 for blocks produced from replacement with rice husks. There was obvious decrease in bulk densities of all blocks with respect to percentage replacement with either sawdust and rice husks respectively.

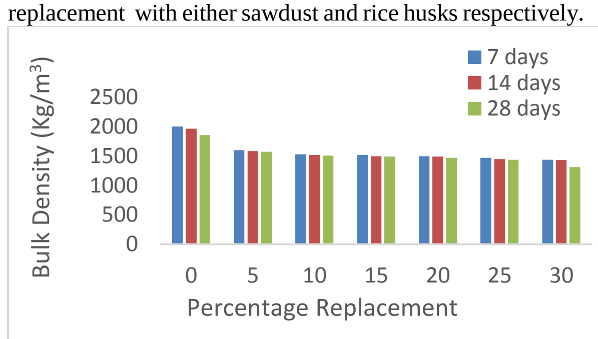

Figure 5: Bulk density of blocks made from replacement with sawdust

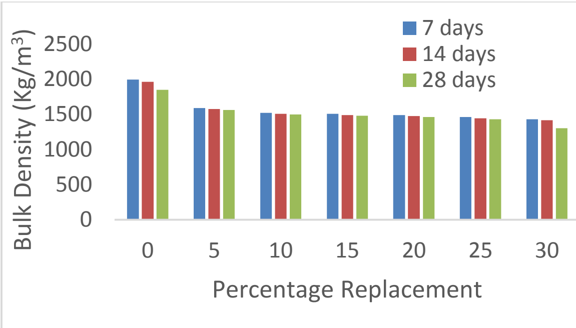

Figure 6: Bulk density of blocks made from replacement with Rice Husk

For replacement with sawdust and rice husks respectively, the maximum bulk densities were recorded at 5% replacements while the minimum values were recorded at 30% replacement. The maximum values at the different curing ages were 1597, 1583 and 1570 Kg/m^3 for replacement with sawdust, and 1592, 1578 and 1566 Kg/m^3 for replacement with rice husk. The minimum values were 1436, 1428 and 1309 for replacement with sawdust; and 1431, 1416 and 1303 Kg/m^3 for replacement with rice husks.

For replacement with sawdust and rice husk respectively, 61. 11% of the tested blocks were of bulk density values less than the minimum of 1500 Kg/m^3 specified in British Standard Institute (2002). Comparative analysis of the results revealed that the blocks from partial replacement with sawdust were of higher bulk densities than the blocks from partial replacement with rice husks. This is graphically displayed in Figure 7.

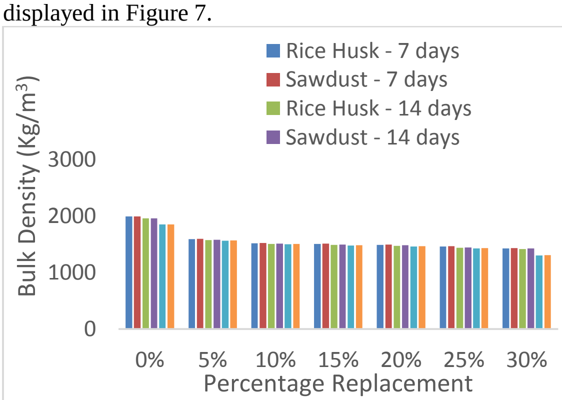

Figure 5: Bulk densities compared for both replacement

Conclusions

The compressive strengths of blocks decreased with increase in percentage replacement of sand but increased with increase in curing age. The maximum strength for replacement with sawdust was 1.77 N/mm^2 at 5% replacement and curing age of 28 days; while the minimum strength was 0.33 N/mm^2 and was recorded at 30% replacement and curing age of 7 days. Maximum strength of 0.79 N/mm^2 at 5% replacement with rice husk and curing age of 28 days was recorded; while the minimum strength was 0.30 N/mm^2 and was recorded at 30% replacement and curing age of 7 days. For both replacements at the different curing ages, the maximum strengths were recorded at 5% replacement, and the minimum strengths were recorded at 30%.

Only the blocks produced from replacement with sawdust at 5% replacement and 28 days curing age were of acceptable standard because the strengths of the tested blocks at this replacement were greater than 1.75 N/mm^2 stipulated in Federal Building Code (2006). None of the blocks produce from partial replacement with rice husk had strength equal in value to the 1.75 N/mm^2 stated in the Federal Building Code (2006). Comparison of blocks from partial replacement with sawdust and partial replacement with rice husks revealed that the blocks produced from partial replacement with sawdust were of higher strengths compared with the blocks from partial replacement with rice husks.

The water absorption capabilities of the blocks grew with increase in percentage replacement of sand with sawdust and rice husks respectively. The water absorption capabilities of blocks produced from replacement with rice husks were higher than those of blocks produce from replacement with sawdust. For replacement with both materials, the highest water absorption capacities were recorded at 30% replacement, the lowest values occurred at 5% replacements. When compared with the minimum standard (12%) of water capacity set in Federal Building Code (2006), the blocks from both replacements generally performed poorly in terms of water absorption capacity. For replacement with rice husk, only blocks produced at 5% replacement had water absorption capacity (11.34%) < 12% provided in Federal Building Code (2006). In the case of replacement with sawdust, blocks produced at 5% and 10% replacements had water absorption capacities 10.50% and 11.44% respectively less than 12% set in the Federal Building Code (2006).

There was obvious decrease in bulk densities of all blocks with respect to percentage replacement of sand with either sawdust and rice husks respectively. For replacement with sawdust and rice husks respectively, the maximum bulk densities were recorded at 5% replacements while the minimum values were recorded at 30% replacement. For replacement with sawdust and rice husk respectively, 61. 11% of the tested blocks were of bulk density values less than the minimum of 1500 Kg/m^3 specified in British Standard Institute (2002). The blocks from partial replacement with sawdust were of higher bulk densities than the blocks from partial replacement with rice husks.

References

Agus S.M. (2002). “Utilization of Uncontrolled Burnt Rice Husk Ash in Soil Improvement”, Dimensi Teknik Sipil, Vol.4 (2), pp.100-105.

Alireza N. G., Suraya A. R., Farah Nora A. Aziz and Mohamad A. M.S. (2010). “Contribution of Rice Husk Ash to the Properties of Mortar and Concrete: A review”, Journal of American Science, 6(3), pp.157-165.

Atikpo, E., Ukala, D.C., Iwemah, E.R. and Agori, J.E. (2018). Construction Feasibility of Papercrete Blocks Produced from Recycled Abandoned

Papers. The Journal of the Nigerian Institute of Production Engineers. Vol. 22, pp. 322-330

Atikpo E., Ukala D. C., Agori J. E., Agbi G. G., Iwemah E. R., Umukoro L. O.and Michael A. (2019). Engineering Feasibility of Building Blocks Produced from Recycled Rice Husks. Nigerian Journal of Environmental Sciences and Technology (NIJEST). Vol. 3(2), pp 410-415.

British Standard 5628-Part 1: (2005) Code of practice for the use of masonry. Structural use of unreinforced masonry.

British Standard 6073-Part 2: (1981) Precast Concrete Masonry Units. Method for Specifying Precast Masonry Units.

British Standard Institute (BSI), (2002). Specification for Clay Bricks and Blocks, BS1200, London.

De Silva S and Uduweriya R.B.(2011). "Investigation of the Properties of Concrete Containing Rice-Husk-Ash" Transactions of the Institution of Engineers, Sri Lanka, pp. 71-79.

Eboziegbe P. A. and Mizi F. (2014) Development of wood-crete from treated sawdust. Construction and Building Materials Volume 52, 15, 353-360 .

Federal Building Code (2006) in Parameters for Good Site Concrete Production Management Practice in Nigeria, In: PhD Thesis by Anosike, M.N., (2011) and Submitted to the Department of Civil Engineering, Covenant |University, Ota, Nigeria.

Josh G. (2017). Sands mafias and vanishing islands: How the world is dealing with the global sand shortage. Science Correspondent. .

Mageswari and Vidivelli B (2009). The use of sawdust ash as fine aggregate replacement in concrete. Journal of Environmental Res. Dev. 3(3) 720-726.

Marcus F (2017). Sand becomes increasingly scarce and expensive. threatening glassmaking and construction. 11 October 2017

Mateusz S, Marek M, Maciej B, Ewa G (2015). Mechanical properties of sawdust and woodchips, Fuel 159, 900–908.

MIDA. 'Manufacturing Wood Industry'. Malaysian Investment Development Authority. Available from http://www.mida.gov.my/home/wood-industries/posts/ (Accessed on 30 April 2018).

MTIB. National Timber Industry Policy 2009-2020. Ministry of Plantation Industries and Commodities Malaysia. (2009).

Shafini M, Shafie Z O and Norsiah H (2017). Potential Utilisation Of Wood Residue In Kedah: A Preliminary Study. Journal of Technology and Operations Management – Special Issue, 60-69.

Subramani, T. and Ravi, G. (2015), Experimental Investigation of Coarse Aggregate with Steel Slag in Concrete, 5(5), pp. 64-67.

The conversation (2017). The world is facing a global sand crisis. The conversation Academic Rigorous, Journalistic flair. (2017).

Theodore W. Marotta, John C. C, Cynthia B L and Christine L (2011). Basic Construction Materials. Pearson Education Inc.