RECYCLING FINE SANDCRETE BLOCK WASTE (FSBW) AS FINE AGGREGATE IN THE PRODUCTION OF SANDCRETE BLOCK

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ABSTRACT
The study investigated the use of Fine Sandcrete Block Waste (FSBW) as fine aggregate in the production of sandcrete blocks with a view of controlling waste and decongesting block molding production sites. Standard sandcrete blocks of size 450mmX225mmX225mm were prepared from a mix ratio 1:6 (cement: fine aggregate) containing sand and FSBW as fine aggregates. The sand was partially replaced by FSBW in the mix within the range 0% - 90% in steps of 10%. The blocks were cured for 28 days and then tested for compressive strength. The physical properties of both the sand and FSBW were also determined. The results of the study revealed that the physical properties of FSBW compares favorably with those of conventional sand with the exception of water absorption. It further showed that the density and the compressive strength of the tested blocks decrease as the percentage replacement of sand with FSBW increases. The density of the blocks varied linearly with the compressive strength. Blocks prepared for mixes having 50% FSBW content or less were found to satisfy the minimum recommended compressive strength of $3.45N/mm^2$ (NIS 87:2000).

Keyword: *sandcrete blocks, recycled aggregate, sustainable construction*.

1. INTRODUCTION

Climate change is one of the world's foremost concerns of this current time and one of the ways the building construction industry is contributing its own quota is in the development of green building or otherwise known as sustainable construction.

The common objective of green or sustainable buildings is designed to reduce the overall impact of the built environment on human health and the natural environment by efficient use of energy, water, and other resources; protect occupant's health and improve employee's productivity; and reducing waste and pollution. One of the ways of achieving the last objective in relation to construction practice is by reuse and recycling of building materials. A major source of material for reuse and recycling is construction and demolition (C & D) wastes.

From findings in Umoh (2012) [1], Crushed Waste Sandcrete Block (CWSB) aggregate can be used as fine aggregate in concrete production and can effectively replace the conventional fine aggregate, sand, in concrete by 50% in medium strength concrete of $30N/mm^2$ target strength.

According to the Inner City Fund (ICF, 1995) [2] report prepared for the United States Environmental Protection Agency Office of Solid Waste, C&D waste is generated from the construction, renovation, repair, and demolition of structures such as residential and commercial buildings, roads, and bridges. The composition of C&D waste varies for these different activities and structures. C&D waste is usually composed of wood products, asphalt, drywall, and masonry; other components often present in significant quantities include metals, plastics, earth, shingles, insulation, paper and cardboard. In same report, leachates from C&D wastes landfills are confirmed to have contaminated the ground water beyond acceptable levels thereby constituting contamination problems to the environment.
Stokoe *et al.* (1999) [3] in Wahab and Lawal (2012) [4]reported that construction and demolition (C&D) waste took up about 65% of Hong Kong's landfill space at its peak in 1994/1995. According to Ferguson *et al.* (1995) [5], over 50% of the waste in a typical United Kingdom landfill could be construction waste. Craven *et al.* (1994) [6] reported that construction activity generates 20 to 30% of all waste deposited in Australian landfills. In the United States of America, C&D waste represents about one-third of the volume of materials in landfills. Serpell and Labra (2003) [7] reported that of the 3.5 million tons of C&D waste generated in Chile, only 10% is placed in authorized and controlled landfill sites.
The use of sandcrete blocks in Nigeria dates back to the colonial era in the late nineteenth and early twentieth century. Buildings are not made to last forever and so most of the buildings that are over a hundred years are now being demolished. Also, in the context of urbanization in Nigerian, a lot of homes are being demolished and a recent example is the five hundred (500) housing units estate demolished in Abuja, Nigeria, as reported in The Sun

Newspaper (2012) [8]. Over three thousand (3000) houses have been earmarked for demolition at Bassa Jiwa village, Airport road, Abuja (Thisday Newspaper, 2012) [9].
All these C&D debris will constitute nuisance to the environment if not put to reuse either by recycling or any other means. As it can be seen from Plate 1, the bulk of the debris is broken sandcrete blocks since all the walls were all made from sandcrete blocks.

PLATE 1: A view of part of the demolished 500 housing unit in Abuja. (The SUN, 2012) [8].

2. MATERIALS AND METHODS

2.1 Materials

The materials used in this study are Ordinary Portland Cement (Dangote brand (42.5N)) that complies with the specifications in NIS 444-1:2003[10] and BS EN 197-1:2000 [11].

The fine aggregate used is sand obtained from the beddings of a large water stream. The sand was sieved with the 5mm sieve and deliberately kept in the laboratory to exclude it from rain.

Due to the sharp practices of the local sandcrete block producers that translate in the production of lower quality blocks as observed by Anosike and Oyebade (2012) [12] amongst many others, the Fine Sandcrete Block Waste (FSBW) used in this study was prepared from laboratory molded standard sandcrete blocks. The FSWB was prepared by batching and mixing the cement and sand, mix ratio 1:6, with water to obtain a low but workable mortar mix that will not shatter when demoulded to produce mortar for the simulated blocks as recommended in NIS 87:2000 [13] for sandcrete blocks. These blocks were cured by sprinkling three (3) times daily with water after 24 hours of production for twenty eight (28) days and left for a month further. The mortar was then carefully crushed by blowing them in jute bags so as not to crush the sand grains used in the mortar production and sieved with a 4.75mm sieve.

The water used in this study was the pipe borne water of quality deemed fit for drinking.

2.2 Methods

Sieve analysis, field settling (silt) test, bulk density test and specific gravity test were performed on both the sand and the FSBW to enable fair comparisms of their properties to be made.

Standard sandcrete hollow blocks of size 450mm X 225mm X 225mm were produced first with the sand, cement and water, mix ratio 1:6, to a low but workable consistence (0% FSBW) to NIS 87:2000 [13]. Other hollow sandcrete blocks were produce with the blended sand and FSBW as fine aggregates such the FSBW partially replaces the sand by 10% to 90% in steps of 10%. It was observed that at higher percentage replacement with FSBW, more water was needed to reach the same workable consistence. A total of five (5) samples were produced for each percentage replacement and a total of fifty five (50) sandcrete blocks were produced. The sandcrete blocks were moulded by vibrating its freshly mixed content in a block moulding machine-mould and vibrated with a 5.0KVA powered engine. The blocks were allowed to cure for twenty eight (28) days by sprinkling thrice daily, once each in the morning, noon and evening except on the 28th day where water was sprinkled only once in the morning and allowed to dry out.

Each block sample was weighed and crushed on a balance and a compression test was performed to determine its compressive strength.

3. RESULTS AND DISCUSSIONS

3.1 Physical properties of the fine aggregates

It is observed in Table 1 that the FSBW has a reduced specific gravity, bulk densities and greater silts than the sand. The reduced values could be attributed to the increased fines in the FSBW because the fines are lighter particles than sand particles. The water absorption is also higher with the FSBW and this implies that the higher the percentage replacement with FSBW, the more porous the resulting sandcrete blocks will be. This also explains why there is higher water demand to attain same consistence with lower replacements percentages with FSBW.

Table 1: Physical properties of the fine aggregates.

Properties	Sand	FSBW
Specific Gravity (G)	2.71	2.68
Loose bulk density (LBD)	1581 Kg/m^3	1535 Kg/m^3
Compacted bulk density (CBD)	1633 Kg/m^3	1611 Kg/m^3
LBD:CBD ratio	0.95	0.95
Field settling silt test	5.04%	7.05%
Water absorption	8.54%	32.85%

Sieve Analysis

As observed from Fig.1, both fine aggregate samples used are well graded. The two (2) curves are between both upper and lower limits' curves signifying that both fine aggregate curves falls within the grading limits for zone one of BS 882 aggregates and therefore suitable for use as fine aggregate in sandcrete block production.

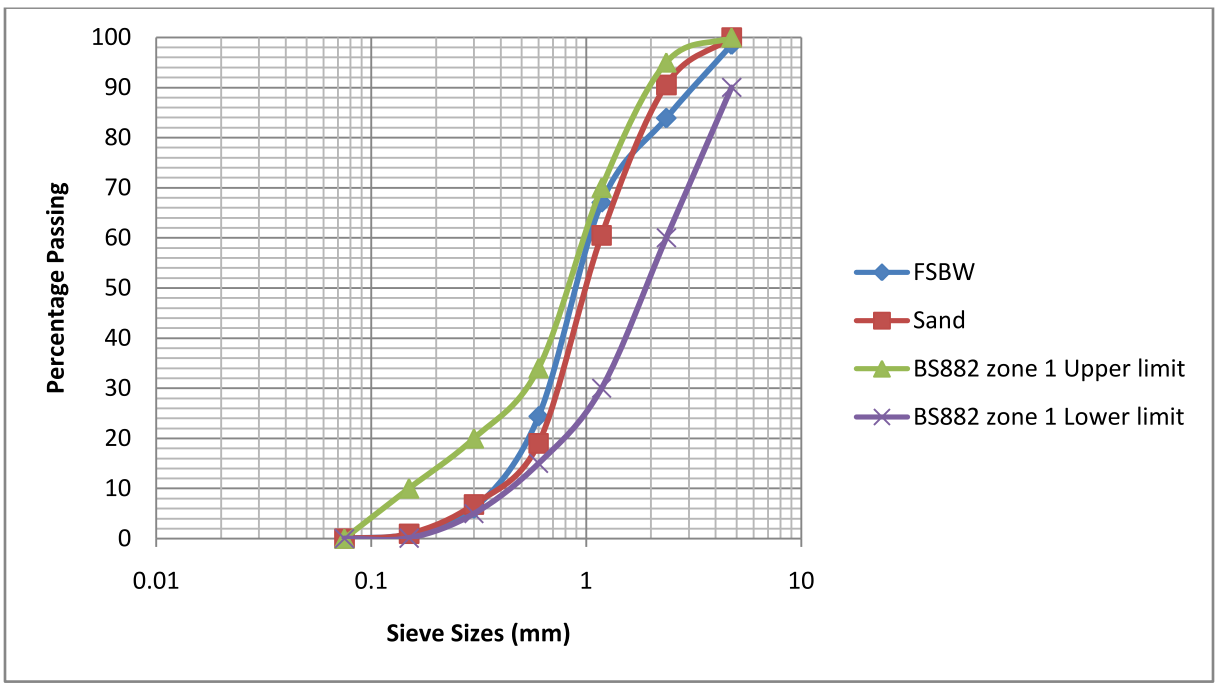

Figure 1: Sieve analysis of the sand and FSBW fine aggregates and the limits of zone 1 aggregates to BS 882:1973.

3.2 Compressive strength

In Fig. 2, it could be observed that the compressive strength of the tested sandcrete blocks decreases with an increase in FSBW content. This may be attributed to the presence of more fines in the FSBW aggregates and higher water cement ratio since more water was added to attain approximately same workable consistence as lower replacements.

The Standard Organization of Nigeria (SON) through NIS 87:2000 [13] recommends that a load bearing 450mm X 225mm X 225mm sandcrete block must posses a minimum of 3.45N/mm^2 compressive strength.

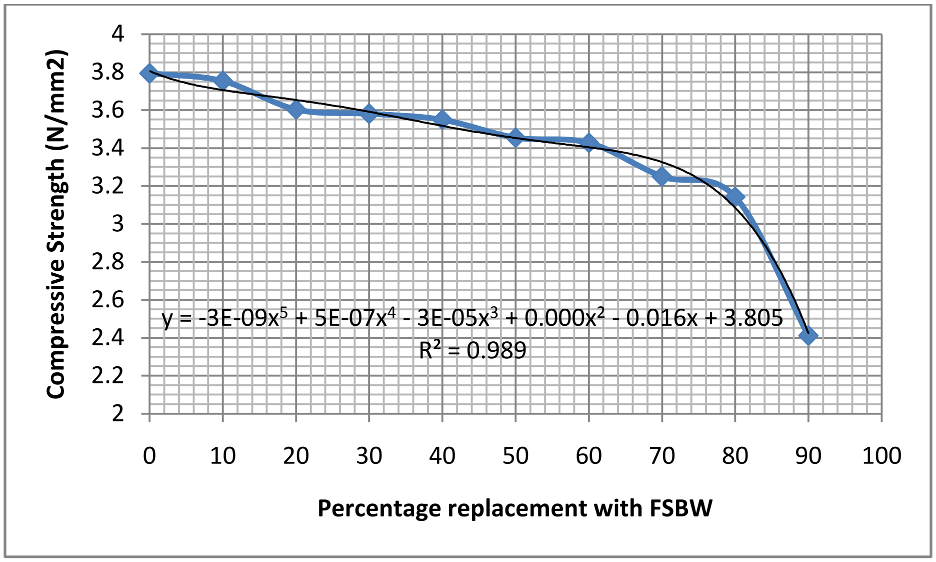

Figure 2: Compressive strength of various percentage replacements with FSBW.

3.3 Density of Sandcrete Blocks

Fig. 3 shows the various densities of the sandcrete blocks produced from different percentage replacement of sand with FSBW aggregates. It was observed that the more FSBW replacement, the lesser the density of the blocks. This signifies that the FSBW aggregate is lighter than sand. This is explained by the lower bulk densities of the FSBW aggregate are less than that of sand as shown in Table 1.

The content of the fines are the likely reason for these differences since they need more water for a workable consistence and this increases the porosity of the blocks with higher replacements with FSBW aggregates.

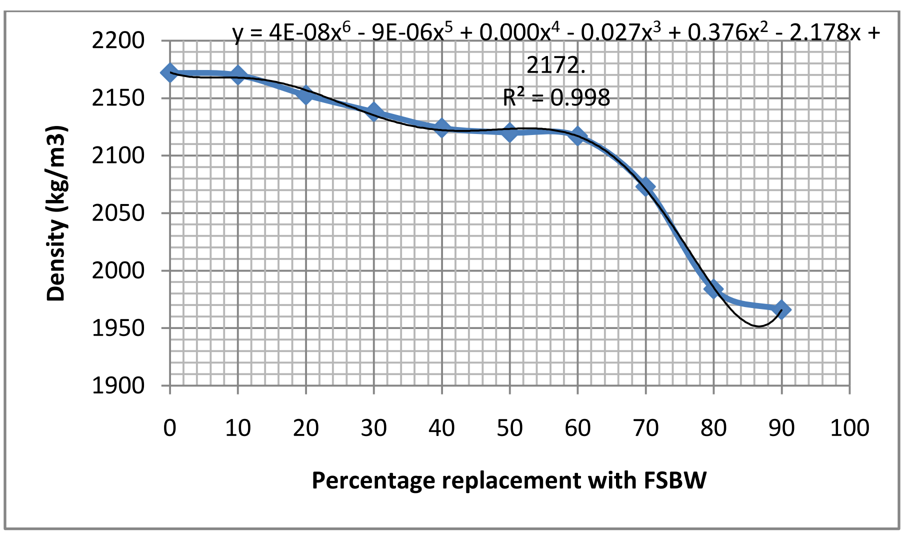

Figure 3: Densities of various percentage replacements with FSBW.

3.4 Compressive strength and density relationship

It was also observed from Fig. 4 that the compressive strength of the sandcrete blocks is proportional to the density. The relationship is approximately a linear one.

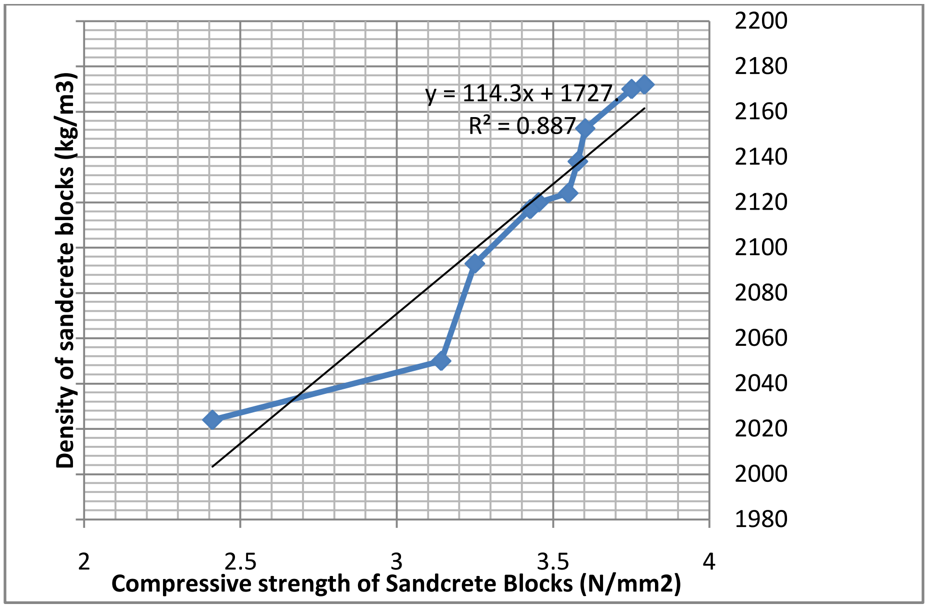

Figure 4: Sandcrete Block Density and Compressive Strength Relationship.

4. CONCLUSION.

i. The sand and FSBW met the aggregate requirement for zone one (1) grading limits (BS 882:1973) of fine aggregates and therefore suitable for use in sandcrete block production.
ii. The silt content present in the FSBW aggregates is 7.05% which is below the maximum limit of 8% as specified in BS 882: 1973.
iii. The silt content present in the FSBW is 7.05% which is below the maximum limit of 8% specified in BS 882:1973.
iv. There are reductions in both bulk densities of the FSBW compared to sand despite the fact that the FSBW aggregate was prepared with the same sand thereby producing a lower density block with increased replacement with the FSBW. This signifies that the silt is lighter than the sand that it was prepared from.
v. The increase in the silt content is probably due to crushed cement hydrate in the FSBW aggregates because they loose their compaction when the bound and cemented hydrate disintegrate during crushing
vi. This lighter silt is deemed responsible for the reduced density of the sandcrete blocks at higher replacements with FSBW.
vii. There is reduction in strength of the blocks with increasing percentage replacement with the FSBW aggregates.
viii. The greater density blocks posses' higher compressive strength despite the fact that they were compacted with the same controlled condition.
ix. To produce a standard sandcrete block to the Nigerian standard, NIS 87: 2000, the tolerable percentage replacement of conventional fine aggregate with the FSBW is 50%. Beyond this percentage, the compressive strength produced will be below the standard strength of 3.45N/mm^2.

REFERENCES

[1] Umoh, Akaninyene A. RECYCLING DEMOLITION WASTE SANDCRETE BLOCKS AS AGGREGATE IN CONCRETE. ARPN Journal of Engineering and Applied Sciences. VOL. 7, NO. 9, Pg 1111-1118. (2012)

[2] ICF Incorporated Contract No. 68-W3-0008, (1995). Report on the Construction and Demolition Waste Landfills to U.S.A Environmental Protection Agency Office Of Solid Waste.

[3] Stokoe M. J., Kwong P. W., Lau MM Waste reduction: A tool for sustainable waste Management for Hong Kong. In: Barrage A, Edelman Y, editors. Proceedings of R'99 World Congress, Geneva: EMPA, 5: 165-170. (1999).

[4] Wahab, A. B., & Lawal, A. F. An evaluation of waste control measures in construction industry in Nigeria. African Journal of Environmental Science and Technology, 5(3), 246-254. (2011).

[5] Ferguson J, Kermode N, Nash CL, Sketch WAJ, Huxford RP (1995). Managing and minimizing construction waste, A Practical Guide, Institution of Civil Engineers, London.

[6] Craven D. J., Okraglik H. M. and Eilenberg J. M. Construction waste and a new design methodology, in Kilbert CJ, (ed).Sustainable Construction, Centre for Construction and Environment, Gainsville, FL., pp.89-98. (1994).

[7] Serpell A. and Labra M. A study on construction waste in Chile. In : Ofori G, Ling FY, editors. Proceedings, Joint Symposium of CIB W55, W65 and W107 on Knowledge. Construction 2. October, pp.102-111. (2003).

[8] The SUN. (2012, October 10). Demolition so callous. Retrieved March 4, 2013, from sunnnewsonline: http://sunnewsonline.com/new/cover/a-demolition-so-callous/

[9] Thisday Newspaper. (2012, April 18). Retrieved March 4, 2013 from http://www.thisdaylive.com/articles/fcta-demolishes-illegal-structures/113984/

[10] NIS 444-1:2003. Composition, Specification and Conformity Criteria for Common Cement. Standard Organization of Nigeria (SON).

[11] BS EN 197-1:2000. Composition, Specification and Conformity Criteria for Common Cement. British Standard Institute.

[12] Anosike, M. N., and A. A. Oyebade. Sandcrete Blocks and Quality Management in Nigeria Building Industry. Journal of Engineering, Project, and Production Management. Vol 2(1), 37-46. (2012).

[13] Nigerian Indusrial Standard, NIS 87:2000. Specification for Standard Sandcrete Blocks. Standard Organization of Nigeria.