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Characteristic Strength of Sandcrete Hollow Block with Partial Replacement of Fine Sand with Crushed Glass

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Abstract – Waste management is becoming a major issue for communities worldwide. Glass, being non-biodegradable, is not suitable for addition to landfill and such recycling opportunities need to be investigated. Continuous use of natural resources since ages has been depleting them at an alarming rate. Natural sand is the best form of the fine aggregate used in block production until now. However, continuous sand mining results in impure water in river, which leads to an environment disaster and results in causing pits on lands. In the search for the replacement of sand, construction material waste and environmental waste materials got the focus of research people. Among these materials like waste glass can be an effective replacement for fine aggregate. This project studies the suitability of crushed glass as a possible substitute for conventional fine aggregate. Block industry is one of the largest consumers of natural resources. In this research work, the issue of environmental concern is addressed by the use of crushed glass as partial replacement of fine aggregates in block production. Fine aggregates were replaced by crushed glass as 10%, 20%, and 30% by volume for 1:6 and 1:8 mix. The block specimens were cured with water and MgSO4 respectively. The block specimens were tested for compressive strength at 7 and 14 days of age and the results obtained were compared with those of normal block. The result concluded that 30% replacement is suitable for water curing at both mix ratios while 20% replacement is suitable for sulphate environment for both mix ratios when cured with MgSO4.

Keywords: Sandcrete, Hollow block, Crushed glass, Waste management

1. Introduction

Housing for citizens is one of the major challenges facing humankind in the 21st century. Although studies have shown that the problem of housing is universal, it is, however, more critical in less developed countries (LDCS) including Nigeria. The challenge of housing is not particularly acute to the rural dwellers, it also affects the urban areas in many less developed countries, where expansion of the urban population due to the high population growth rate and a massive rural-urban drift have compounded the housing situation. Building construction industry is one of the most vital sector of most developing and developed nations. Building materials are being considered as the backbone of this industry as they are said to be indispensable to any form of construction or building works.

Sandcrete block is among the most widely used man – made product in the world and is second only to water as the world's most utilized substance. In its simplest form, Sandcrete block is a mixture of river sand, cement and water and it is cured and hardens into a rock- like mass known as block. It has an important advantage in construction work because it can be mould or form into shape when newly mixed either manually or mechanically and is strong and durable when hardened. It is widely acknowledged that the use of secondary and alternative aggregates in construction products contribute sustainable

construction. According to Oikonomou (2005), by replacing part of the natural aggregates, the need of both quarrying and waste disposal systems are reduced with the associated benefits of reduced environmental and social impacts. Mehta (2001) explained it further by saying that environmental impact of the concrete industry can be reduced through resource productivity by conserving materials and energy for making of concrete and by improving the durability of concrete products.

Large quantities of waste glass, especially in the form of empty bottles are thrown away as garbage and the quantity of such glass waste is likely to be on the increase as more & more foodstuffs and drinks are sold in glass bottles and containers. The above poses a disposal problem, which is accentuated by severe restrictions on environmental pollution.

Refuse glass crushed as fine to medium-sized aggregate has been successfully used as replacement of up to 30% for natural aggregate in the manufacture of masonry block. It is generally believed that glass is not suitable for use in concrete because alkali in the cement paste may react with the silica in the glass causing harmful expansion. This alkali-silica reaction (ASR) can occur in concrete produced with many other types of aggregate, and the problem has been extensively studied. (Malik et al., 2013).

When waste glasses are reused in making sandcrete block, the production cost of the block will go down. However, deleterious alkali-silica reaction might occur in glass concrete due to its high silica constituent. Some solutions have been formed to alleviate alkali-silica reaction, but these solutions have some limitations, which made it still particularly important to investigate the utilization of glass in block. The limitations include the long-term inspecting of the effectiveness of alkali-silica reaction suppressants. (Kuttimarks and Shruthi 2014)

Recent studies which have focused on the suitability of using waste glass as a partial replacement for fine aggregate have found promising results. One crucial finding from this research has been that glass colour has no influence on block properties (Park et al., 2004), eliminating the need to sort post-consumer glass by colour, and thus making this an attractive form of recycling).In spite of its potential reactivity, crushed glass has a number of properties that makes it a very attractive fine-aggregate for block production, these includes:

1. Because it has basically zero water absorption, it is one of the most durable materials known to man. With current emphasis on the durability of block, it is only natural to rely on extremely durable materials.
2. The excellent hardness of glass gives the block an abrasion resistance that can be reached only with few natural stone aggregates or the addition of metallic fines typical of special floor toppings.
3. For a number of reasons, glass aggregate improves the properties of sandcrete block so that high strength can be obtained.
4. The aesthetic potential of colour-sorted glass, not to mention specialty glass, has barely been explored at all and offers numerous novel applications.
5. Very finely ground glass has pozzolanic properties and therefore can serve both as partial cement replacement and filler. (Meyer *et al*, 2001)

2. Methodology

This work was based on the laboratory test that carried out on sandcrete block with crushed glass. This stage involved batching of materials and mixing, moulding of the blocks, curing and testing. The constituents of crushed glass sandcrete block were measured using certain chosen parameters such as mix ratios at varying percentage of crushed glass, sand and content. The ratio of the mix used were 1:6 and 1:8 respectively, while varying percentage replacement of crushed glass as fine aggregate, at levels: 10%, 20%, and 30%;

Immediately after mixing, the test specimens were mould using metal mould of size 450mm x 225mm x 150mm. filled with the mix, vibrated and compacted properly and the top of the mould was made smooth

with small timber log., and after 24 hours the block specimens are subjected to curing, for 7 and 14 days respectively. The block specimens were separated into two, one part was cured by sprinkling with water and other part was cured by sprinkling with 5% of Magnesium Sulphate (MgSO4) for the curing age, the curing process was carried out in a place free from rainwater, vibration and not exposed to direct sunlight or other sources of heat.

At the required curing ages of 7 and 14 days, the specimens were tested for compression strength with the use of compression-testing machine.

3. Data Collection, Analysis and Presentation

Table 1: Chemical composition/properties of cement, natural sand and crushed glass.

S/N	Parameter (%)	Cement	Natural sand	Crushed Glass
1	SiO_2	20.8	88.54	72.08
2	Al_2O_3	4.6	1.21	2.19
3	Fe_2O_3	2.8	0.76	0.22
4	CaO	65.4	5.33	10.45
5	MgO	1.3	0.42	0.72
6	SO_3	2.2	--	--
7	Na_2O	0.31	0.33	13.71
8	K_2O	0.44	0.31	0.16
9	TiO_2	--	0.05	0.1
10	Cr_2O_3	--	--	0.01

Source: Tan, K. H., and Du, H (2014)

Table 1 shows the Chemical composition/properties of cement, natural sand and crushed glass. When comparing the constituents of crushed glass, it could be deuced that the crushed glass has cementitious properties and this could add to the strength of the sandcrete block.

Table 2: Compressive Strength (N/mm^2) of Specimens, cured with water and $MgSO_4$:

	Water curing				**$MgSO_4$ curing**			
Percentage Replacement	Mix 1:6		Mix 1:8		Mix 1:6		Mix 1:8	
	7 days	14 days	7 days	14 days	7 days	14 days	7 days	14 days
0 %	1.42	2.18	1.09	1.14	1.59	1.84	0.96	1.31
10 %	1.77	1.80	0.90	1.12	2.12	1.87	1.0	1.06
20 %	1.93	2.12	1.87	2.03	2.30	2.06	2.24	2.24
30 %	2.03	1.53	1.81	2.43	2.28	1.53	1.4	1.31

Source: Experimental result 2018

Figures 1 – 4 show the graphical representation of compressive strengths of the glasscrete block specimens.

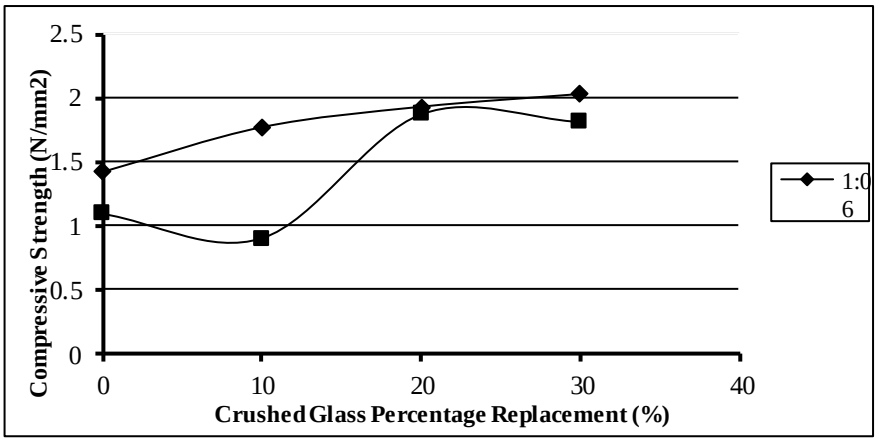

Figure 1: Graph showing strength of sandcrete hollow block with mix 1:6 and 1:8 cured with water for 7 days

From the graph in Figure 1, it can be deduced that maximum strength was attained with mix 1:6 when 30% of glass replacement was used and with mix 1:8 at 20% replacement, which is 2.03 and 1.87N/mm^2 respectively.

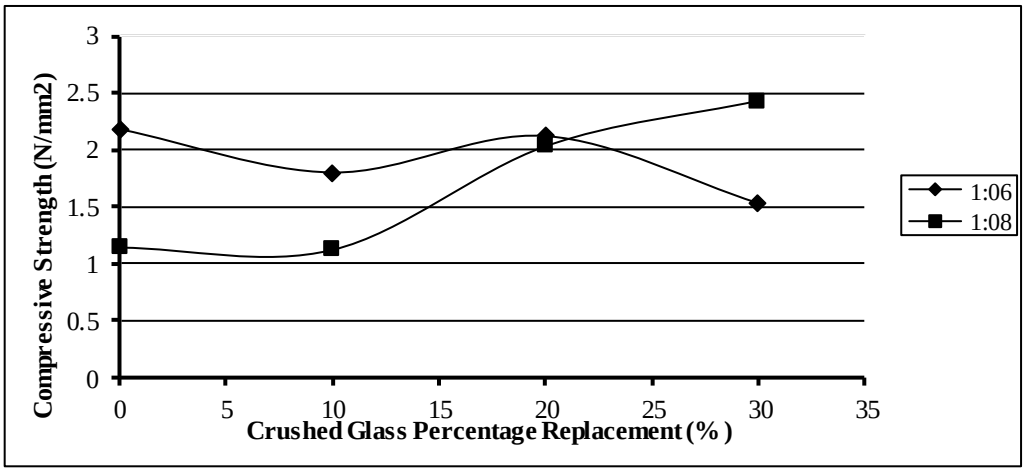

Figure 2: Graph showing strength of sandcrete hollow block with mix 1:6 and 1:8 cured with water for 14 days

From the above graph, it can be deduced that maximum strength with mix 1:6 and 1:8 is at 0% and 30% rep, which is 2.18 and 2.43N/mm^2 respectively. It can also be deduced that there is an increase in strength in mix 1:6 at 14 days curing.

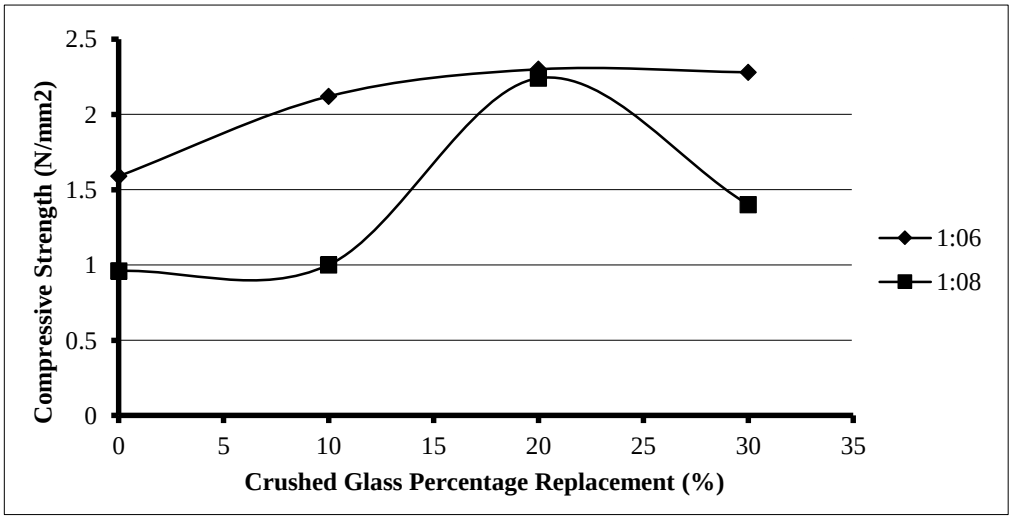

Figure 3: Graph showing strength of sandcrete hollow block with mix 1:6 and 1:8 cured with $MgSO_4$ at 7 days

From the above graph it can be deduced that maximum strength with mix 1:6 and 1:8 is at 20% replacement of crushed glass which is 2.30 and 2.24N/mm^2 respectively. It can also be deduced that there is an increase in strength in mix 1:6 at 7 days curing.

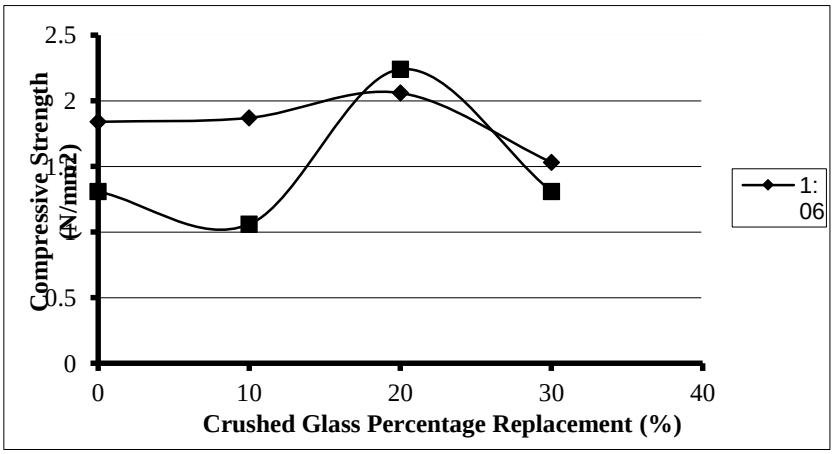

Figure 4: Graph showing strength of sandcrete hollow block with mix 1:6 and 1:8 cured with MgSO4 at 14 days

It could be deduced from the graph that maximum strength with mix 1:6 and 1:8 is at 20% replacement level of crushed glass, which is 2.06 and 2.24N/mm2 respectively and that there is an increase in strength in mix 1:6 at 14 days of curing than that of mix 1:8.

4. Conclusion

Based on the experimental results, the following conclusion can be drawn concerning the characteristics strength of sandcrete hollow block, using crushed glass as partial replacement for fine aggregate when cured with Water and $MgSO_4$ at a solution of 5% of each of the salt respectively at 7 and 14days:

i. There is an increase in strength of the block cured with water as the day of curing with water increases. The strength of the mix 1:6 increases as the days of curing with water increases, also as mix 1:8 do increases in strength as the curing day increases.
ii. There is also a decrease in the strength of the block cured with $MgSO_4$ as the day of curing with $MgSO_4$ increases. The strength of the mix 1:6 decreases as the days of curing with $MgSO_4$ increases, also as mix 1:8 do increases in strength as the curing day increases.
iii. There is also an increase in the strength of mix 1:6 than mix 1:8 throughout the curing day (both 7 and 14 days) irrespective of the curing medium (i.e. both water and $MgSO_4$).

From the above it can be concluded that 30% replacement is suitable for water curing at both mix ratio 1:6 and 1:8 while 20% replacement is suitable for sulphate environment for both mix ratio 1:6 and 1:8 when cured with $MgSO_4$.

5. Recommendations

Following the observation from the results, the following are there by recommended for effective use of sandcrete with crushed glass:

i) Crushed glass as partial replacement for fine aggregate can be used at 30% replacement in mix 1:6 at 7 days curing age with water and 20% replacement in mix 1:6 at 14 days curing age with water. While 20% replacement in mix 1:8 at 7 days and 30% replacement in mix 1:8 at 14 days when cured with water.
ii) Crushed glass as partial replacement for fine aggregate in sandcrete hollow block can also be used at 20% replacement in sulphate environment (i.e. MgSO4 curing) irrespective of the curing age, both 7 and 14 days.
iii) It is here by recommended that 30% replacement of glass as fine aggregate is suitable to produce block, which is to be cured with water, and 20% replacement of crushed glass as fine aggregate is also suitable for block to be used in sulphate environment (MgSO4) respectively.

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