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Development Of Sandcrete Block Using Cassava Waste Water As An Admixture

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Abstract: - Sandcrete blocks produced commercially in Akure have failed to meet the minimum requirement of Nigerian Industrial Standard (NIS 2000; 87: 2000) 2.5N/mm^2 to 3.45N/mm^2. Researchers have attributed this to soil, mix ratio, curing, and control. The purpose of the study is to use cassava waste water as an admixture to improve the quality and the compressive strength of Sandcrete blocks produced in Akure. A total of 60 sandcrete blocks size 450mm X 150mm X 225mm were produced using an admixture of 5%, 10%, 15% and 20% of Cassava waste water with 0% control, and cured for 7, 14, 21, and 28 days. The tests performed include: sieve analysis, Moisture content, Specific Gravity, Water absorption and Compressive Strength. All tests were performed to ascertain if cassava produced sandcrete blocks conform with (NIS 87: 2000, NIS: 2000) recommendations. The results obtained indicate that 20% admixture satisfies NIS requirements (3.30 N/mm^2).

Keyword: *Sandcrete block, sieve analysis, water absorption specific gravity compressive strength*

I. INTRODUCTION

The use of sandcrete blocks has gained popularity in Nigeria including Ondo State. They are widely used as walling units or partition, often as a load bearing walls. Investors are moving away from the idea of molding blocks on sites due to rising cost of labour. As a result building investors consider buying directly from the block industries. In Ondo State, the quality of sandcrete blocks manufactured varies, due to the method of Production employed by individual block industry. The quality of sandcrete blocks produced generally in Nigeria has reduced due to demand and lack of control by government agencies. The problem of poor block quality emerged because of the recent increasing building collapsing in Ondo State and other parts of the country. Dov. (1991) described sandcrete blocks as precast masonry units assembled and bounded by cementitious materials to form wall which can be either load bearing wall, enclosed wall or back up wall. According to BS 6073 (Specification for Precast Concrete Masonry Unit Part 1), three types of blocks are displayed and recognized and they are: solid, hollow and cellular. They are molded or produced in various sizes. Commonly used sizes are (150mm X 225mm X 450mm, 225mm X 225mm X 450mm) for load bearing and non-load bearing structures with a wide range of thickness from 60mm to 250mm (Hodge 1971). The load bearing walls are those walls that can support the entire structure and transmit the load to ground surface (NIS 87:2000). According to NIS 87:2000; sandcrete blocks pose intrinsic low compressive strength, indicating that they are susceptive to any natural disaster such as earth quakes or seismic activities. Previous studies have also indicated that sandcrete blocks are produced in various standards and some are below the requirement standards for the construction of the buildings. The deficiency found is that sandcrete has no standard engineering definition. The engineering definition of sandcrete is to suit the purpose of use. Sandcrete blocks are rough in physical appearance; due to the nature and origin of pure morphological definition. However, there is a general engineering materials standard definition such as sand, cement and water. In addition, the application of Geotechnical methods such as sieve analysis, silt/clay content and bulk density appeared to have consolidated engineering definition. The time mixing sandcrete with cement and also the time lapse between mixing compaction appear to have direct impact on the strength. Increase in strength with age and curing temperature, also seems to contribute to stabilization of sandcrete. Neville, (2000) identified that the compressive strength of a sandcrete materials increases cement contents with limit rate. The type of sand materials used, such as fineness, density, relative density and sharpness seems to have direct influence on easy mixing with cement. Ezeji (1997) indicates that the relatives' proportions and number of components considerably affect the mixing rate with cement. Similarly, Andram (2004) showed that commercially sandcrete blocks produced exhibit compressive strength far below standard recommendation for construction. He went further to indicate that the maximum compressive strength of commercially produced sandcrete blocks was within range of 0.5-0.97N/mm^{2}as against miximum recommended standards of 2.5 -3.45 N/mm ^{2}. The purpose of this study is to determine the compressive strength of sandcrete blocks made of cassava waste water as an admixture and to verify whether it satisfies NIS, NIBRRI and BS requirements, and also to develop a sustainable construction and building material using locally available material that is cheap and avoidable across all classes of the society.

1.1 CASSAVA WATER

Cassava is a perennial woody shrub with an edible root, which grows in tropical and subtropical areas of the world. Cassava originated from tropical America and was first introduced into Africa in the Congo basin by the Portuguese around 1558. Today, it is a dietary staple in much of tropical Africa. Cassava contains 2 cyanogenic glycosides, linamarin (80% of total glycosides) and lotaustralin (20%). A cell-wall enzyme liberates hydrogen cyanide (HCN), which is lethal to animals. Hydrogen cyanide concentrations depend on cultivar, environmental conditions, plant age, number of harvest (for the foliage) and on the plant component that is being considered. There is a continuous gradient of HCN content between varieties which are usually divided into two groups (.Peroni 2007)

- **Bitter varieties** with roots containing 0.02-0.03% HCN (DM basis) and leaves containing up to 0.2% HCN (fresh basis) (Murugesrawi et al., 2006). These have to be processed before being used as feed.
- **Sweet varieties** with roots containing less than 0.01% HCN (DM basis) and leaves 0.1% HCN (DM basis) (Murugesrawi et al., 2006). These can be fed raw. Most commercial varieties belong to this group.

Bitter varieties have often longer and thicker roots than the sweet varieties, but there is no simple and safe method to assess HCN content. However, HCN can be relatively easily removed from cassava by-products. Different processes are effective in reducing cyanogenic glycoside including sun-drying, ensiling, and soaking + sun-drying. All these methods have yielded satisfactory results (Salami, 2003; Tewe, 1992). Well-processed cassava peels have generally acceptable levels, below 50 mg/kg (Osei,1989; Nwokoro, 2005b). However, mass HCN poisoning is intensively managed in Nigerian pig farm, where more than half of the herd died within a few hours after consuming boiled and overly ripe cassava peels from a bitter variety, was reported. Treating the surviving pigs with antibiotics and palm oil saved some of them (Sackey, 2002). The purpose of this investigation is to identify if distilled water cassava waste water could be used as an admixture to increase the quality and compressive strength of sandcrete blocks produced in Nigeria specifically Akure.

Plate 1.0 Typical peeled cassava

1.1.2. Analysis of hydrocyanic acid

Hydrogen cyanide (HCN), sometimes called prussic acid, is an inorganic compound with the chemical formula HCN. It is a colorless, extremely poisonous liquid that boils slightly above room temperature, at 25.6 °C (78.1 °F). HCN is produced on an industrial scale and is a highly valuable precursor to many chemical compounds ranging from polymers to pharmaceuticals. Hydrogen cyanide is a linear molecule, with a triple bond between carbon and nitrogen. A minor tautomer of HCN is HNC, hydrogen isocyanide.

Hydrogen cyanide is weakly acidic with a pKa of 9.2. It partially ionizes in water solution to give the cyanide anion, CN^-. A solution of hydrogen cyanide in water, represented as HCN, is called **HYDROCYANIC ACID**. The salts of the cyanide anion are known as cyanides.

1.1.3 Cassava product for animal and hunman consumption

Cassava is a perishable commodity with a shelf life of less than 3 days after harvest. Processing provides a means of producing shelf stable products (thereby reducing losses), adding value at a local rural level and reducing the bulk to be marketed (Phillips et al., 2005). As urban population expand, the demand for more convenience and shelf-stable foods increases. Some cassava foods, such as Garri, tapioca, and attieke, are highly prized by urban populations, and these have managed to retain their markets. Imported food products are important urban foods but there is still a high demand for traditional foods, although they are often considered less acceptable because of concerns of quality and safety (Sanni et al., 2007). In Africa, cassava is currently utilized for two main purposes: human food and industrial usage. Estimates for the percentage of cassava used for industrial utilization range from 5 to 16% while the rest used directly for human consumption. Most of cassava's industrial utilization is for animal feed. About 10% of its industrial demand consists of high quality cassava flour used in biscuits and other confectioneries, dextrin, pre-gelled starch for adhesives, and starch for pharmaceuticals and seasonings.

1.1.4 Fermentation of Cassava

In industry, as well as other areas, the uses of fermentation progressed rapidly after Pasteur's discoveries. Between 1900 and 1930, ethyl alcohol and butyl alcohol were the most important industrial fermentations in the world. But by the 1960s, chemical synthesis of alcohols and other solvents were less expensive and interest in fermentations waned. However, Plant starch, cellulose from agricultural waste, and waste from cheese manufacture are abundant and renewable sources of fermentable carbohydrates. These materials, not utilized they are buried in waste disposal site or treated with waste water.

Cassava being the sole source of hydrogen cyanide which dissolves in solution to produce hydrocyanic acid is fermented .The roots were peeled, washed and immersed in water in a clean plastic container and shred and put in a muslin bag and submerged in water in a clean plastic container. The temperature of both containers was maintained constantly at of 30^{oC}. The fermentation process of the cassava grated cassava tubers was observed. The fresh, peeled tubers were suspended in water and allowed to ferment for 96hours by the natural micro flora.

After successful fermentation, the cassava waste water containing hydrocyanic acid was collected and carried to the Department of Civil and Environmental Engineering Concrete Laboratory the Federal University Akure where 5%, 10%, 15% and 20% cassava waste water was use as admixture to replace distilled water for the production of sandcrete blocks.

Plate 2.0 The Process of extracting the cassava waste water.

II. STRENGTH AND USAGE OF SANDCRETE BLOCKS

The present Sandcrete blocks commercially produced are unsuitable for load-bearing columns and they can only be used for walling or for foundations if no suitable alternative is available. As material for walls, its strength is less than that of fired clay bricks, but the material is considerably cheaper than fired clay brick. Sandcrete block is the main building material for walling of single-storey buildings (such as houses and schools) in countries like Ghana and Nigeria. Measured compressive strengths of commercially available sandcrete blocks in Nigeria building and construction market fall between 0.5 and 1 N/mm^2, which is well below the 2.5 N/mm^2 legally required for minimum load bearing structure.

III. RESEARCH APPROACH

3.1 SANDCRETE BLOCK PRODUCTION

In this study sandcrete blocks are produced using distil water, cement, sand and cassava waste water as an admixture (5%, 10%, 15% and 20%). The Sandcrete blocks were cast using approved moulds. A total of 12 sandcrete block samples were cast using each proportion (5%, 10%, 15% and 20%) of cassava waste water. A total of 60 sandcrete blocks were cast including control using 100% pure distilled water used vibrating machine. All sandcrete blocks cast are hollow blocks size 150 x 225 x 450 mm. Sieve analysis test was carried out on the soil samples to ascertain their suitability for the block making in accordance to BS 1377. Tests were conducted on water absorption, gravity, penetration, soundness and compressive strength in accordance to BS 3921 and BS 2028.

2.4.2 Mixing

The mixing was done mechanically so as to get a very good proportional mix of the constituent materials for Sandcrete blocks production. All the materials used for the production are cement, fine aggregate, and cassava waste water and distil water. For control samples 100% Distil water was used for the mixed.

2.4.3 Curing

Proper curing methods were used to ensure the blocks attain self strength and they were observed for 7, 14, 21 and 28 days.

3.2.3.2 Water Absorption

The absorption rate is defined as the weight of water absorbed when the unit is partially immersed for 24hours in water as indicated in BS3921.

$$A = \frac{wet\ mass - dry\ mass}{dry\ mass} \times 100 \qquad (1)$$

In this consideration, each sample of Sandcrete blocks was weighed in dried conditions and the readings were recorded, each of these blocks was fully immersed in water for a period of 24 hours to make sure that they were fully submerged in the water. After 24 hours, the wet block samples were removed and weighed. The difference between the dry and wet were taken, and then calculated, using the above equation.

3.2.1.4 Determination of Existing Moisture Content

The moisture content of the soil samples was determined used BS 1377(1991) oven dry method. The moisture content of the soil was calculated as a percentage of its dry weight using the following equation:

$$M = \frac{W2 - W3}{W3 - W1} \text{ x } 100\ \% \qquad (2)$$

IV. ANALYSIS OF TESTS RESULTS

4.1. Specific gravity test

The application of specific gravity was applied, the values obtained are used in the calculation below to determine the specific gravity of fine-grained soil. This result obtained is within block range or limit of NIS and BS..

Specific gravity of soil particles $Gs_1 = \frac{M2-M1}{(M4-M1)-(M3-M2)}$	$\frac{409-269}{(579-269)-(664-409)} = \frac{140}{55} = 2.55$

4.2 **Sieve Analysis results**

The result sieve analysis of the soil samples is the indicated in the figure 4.1 above. The results show is fine grain sand with more than 90 percent passed through 2.36mm about 19.40 percent pass through 75µm. The soil is well graded and it is good for the production of sandcrete blocks (Cc =15).

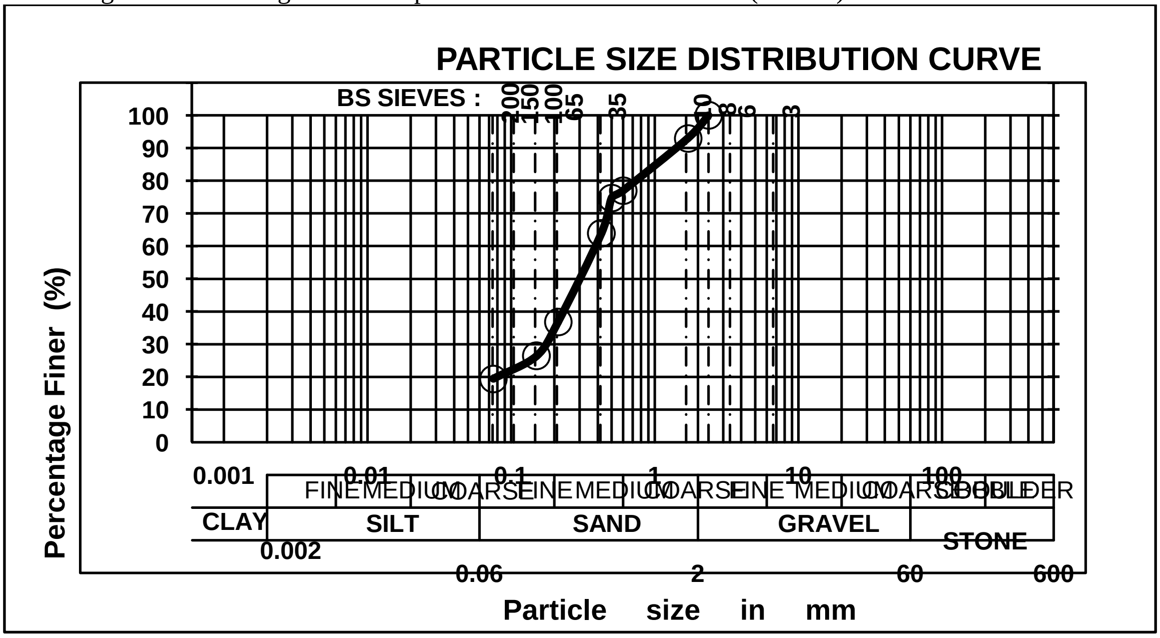

Figure 4.1 Particle size distribution (PSD) of Sample used

4.2.1 Silt/Clay test
Silt clay content test result obtained was 9.33% . the result is within the silt clay context limit.

4.2.2 Moisture Content
The tests result obtained from the average moisture content was 8.19% which is below NIS maximum requirement 12%.

4.3 Water Absorption Rate Day 28

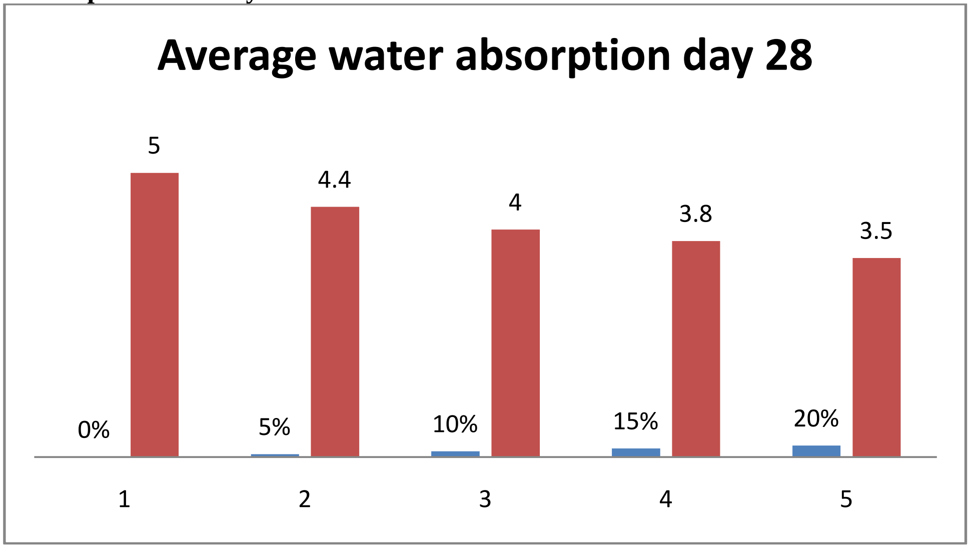

Figure 4.2 Average Water Absorption Rate Day 28

Figure 4.2 above shows the results obtained from the tests of water absorption rate conducted on sandcrete block. As can be seen from the figure the absorption rate varies from 0% control 5%, 10%, 15% and 20% admixtuere. The values are in the figure 4.2 above 0% attained 5%, 5% admixture attained 4.4%, 10% = 4%, 15% = 3.8% and 20% attained 3.5% r All values obtained fell below the maximum NIS recommendation. However, 20% admixture retains water more than both Control and other admixture samples. The water present in mortar would be kept longer than the rest samples.

4.3 COMPRESSIVE STRENGTH TEST
The compressive strength of the samples obtained is shown in the figures 4.3a and 4.3b below, day 7, day 14, day 21, and day 28. Test results indicate that the unit compressive strength for the control samples, 0%, and admixture 5%, 10% and 15%) fall below the recommendation line of NIS and BS for day (7, 14, 21 and 28). For 0% the Compressive Strength values are shown in bracket (0.61, 0.76, 0.99 and 1.03)N/mm^2, while the admixture, 5%, 10% and 15% are also shown in the brackets (0,65, 0.80, 0.88 and 0.99) N/mm^2), (0.72, 0.84, 0.96 and 1.15)N/mm^2, and (0.92, 1.80, 2.11 and 2.41) N/mm^2 The values obtained fall below Recommendations. Whereas 20% cassava waste water as an admixture attained day 7, 14, 21, and 28 are shown in the following values in bracket (0.88, 2.51, 2.72 and 3.30) N/mm^2 day 28 satisfies the NIS and BS requirements. Figures 4.3a to 4.3b show the results and the values of 0%which is the control and the mixtures 5%, 10%, 15% and 20%.

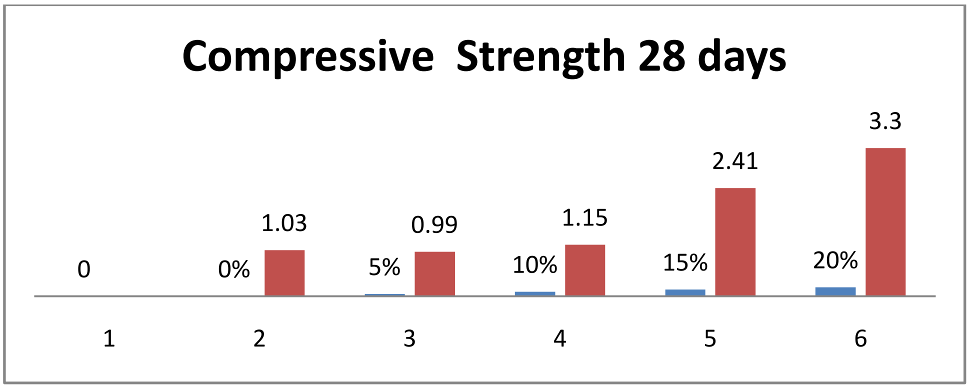

Figure 5.1a Compressive strength obtained 28days

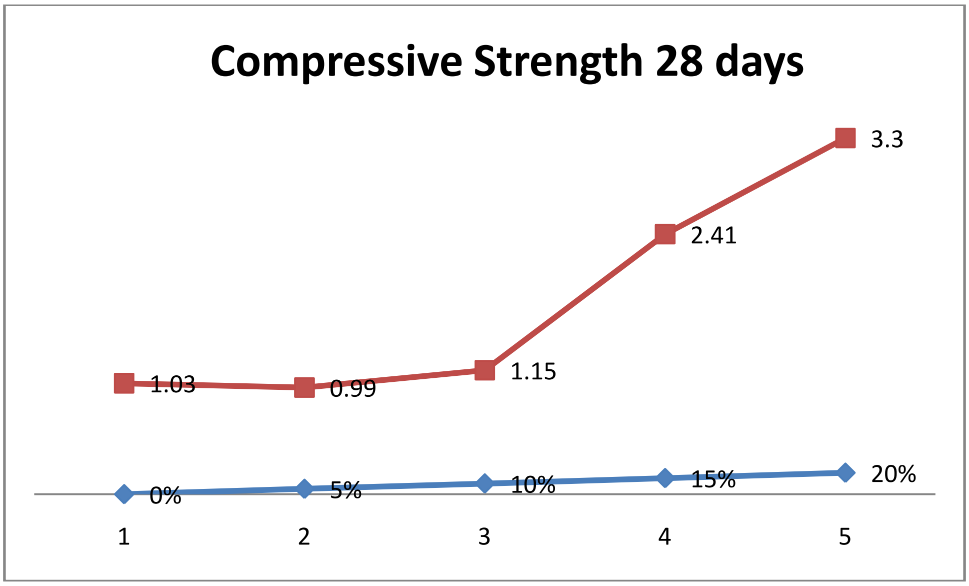

Figure 5.1b Compressive strength obtained day 28

V. CONCLUSIONS AND RECOMMENDATIONS

The test results obtained from analysis showed that the sandy soil components mixed with cement, water and admixture with Cassava waste water is suitable for the production of the sandcrete blocks and also good for construction of a building according to NIS 87: 2004 and NIBBR 2006. The findings show that the compressive strength sandcrete blocks admixed with 20% cassava waste water produced at the Federal university of Technology, Akure, Department of Civil and Environmental Engineering Concrete Laboratory satisfy the requirement of NIS 2004, NIBBRI 2006 and BS 3920 Standard for both Loading and non loading structure. It was observed that the control 100% distilled water 5%, 10% and15% admixture have failed to meet the requirements of NIS, NIBBRI and BS standard. All the 60 sandcrete blocks samples produced and tested have attained day 28 and highest compressive strength.

VI. RECOMMENDATION

Majority of sandcrete blocks commercially produced in Nigeria have failed to meet the requirement standard set down by NIS, NIBBRI and BS. This suggests that there is a need for improvement in this area. More research, more studies are required to be able to develop new alternative sustainable local material to replace old material at low costs. Good Government policies to support and encourage effective education and research on proper management of wastes, safe disposal and recycling. The Authors have suggested that HCN should produced in large quantity be made available in large Urban cities for the production of cassava sandcrete blocks.

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