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Research Paper

Experimental Study of Concrete with Partial Replaced Cement Using Burnt Oyster Shell As An Input For Sustainable Infrastructure Development In Nigeria

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ABSTRACT
Concrete is an inherent material in civil engineering construction works. Its vast application has enhanced recycling of waste materials to wealth products for sustainable infrastructure development. The oyster shell was washed, air dried and crushed to smaller sizes. It was burnt at a temperature of 500^{o}C. The burnt oyster shell was sieved. Concrete cubes of 150mm× 150mm×150mm were designed and casted for both control and partial replaced cement for mix ratios of 1:2:4 and 1:1½:3 by weight. All mixtures were maintained at water/cement ratios of 0.67 and 0.7. The main property investigated was the compressive strength, after curing for 7, 14, and 28days respectively. With mix ratio of 1:2:4, the values for natural cement concrete are 13.03N/mm², 15.01N/mm², 15.20N/mm² respectively, and that of 10 and 20 percent partial replacements were 15.83N/mm²,13.83N/mm², 18.32N/mm² and 16.93N/mm² 15.65N/mm², and 18.49N/mm² respectively. With mix ratio of 1:1½:3, the values of natural cement concrete were 15.84N/mm², 17.25N/mm², and 23.72N/mm² respectively. While those of 10 and 20 percent replacements were 13.83N/mm², 15.78N/mm², 18.32N/mm² and 16.93N/mm², 17.25N/mm², and 23.82N/mm² respectively. Collectively, the results obtained show that the average compressive strength for concrete with partial replaced cement is slightly greater than concrete for control. Therefore, concrete with partial replaced cement is recommended for civil engineering construction works in Nigeria.

Keywords: *Infrastructure, Oyster Shell, Concrete, Waste Minimization, Recycling, Menace, Aggregates, Crustacean.*

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I. INTRODUCTION

Concrete is an inherent material in civil engineering construction works. Its vast application has enhanced recycling of waste materials to wealth products for sustainable infrastructure development.Concrete is the most widely used construction material in the world; its production has always caused massive exploration of natural resources (Adewayi, 2008). However, the basic constituents of concrete are cement and aggregates (i.e. fine and coarse) with water for proportional mixing to gain the desired strength and to perform well during it serviceability state. While the basic ingredients remain the same, their roles remain the same. Cement is a substance that bind alternative materials together; aggregates act as an inert filler to the concrete (Smith *et al.*, 2013). The usage of cement is getting more and more intense with the advanced development in the area of infrastructure. This building material accounts for over 60 percent of the total cost of building construction projects (John, 2006).Every year the seafood industry produces over 100 million pounds (i.e. 45.3 million kg) of waste that is strictly from crustaceans (Skaggs, 2005). This waste that is generated from the industries is simply sent to Landfills. With Landfill space diminishing quickly, civil engineers had been challenged with ways to recycle this waste material to wealth products. Many of the seashells like oyster shell are particularly interesting for recycling and reuse within the concrete and construction industries. The chemical constituents that made up of these shell demonstrate strength properties. It will bind alternative materials together. Furthermore, the geological formation of oyster shell makes it a suitable substitute for coarse aggregate (Skaggs 2005). Also, its

chemical constituents make suitable for partial replacement for cement (Skaggs 2005). Oyster shell is a viable option because they contain large amount of pozzolanic properties and calcium carbonate (Kakisawa & Sumitomo, 2012). This pozzolanic property helps to improve the strength and durability of concrete. Also the calcium carbonate help improve resistance against heat and chemical attack (Kakisawa *et al.*, 2012). Therefore intense application of this burnt oyster shells for cement in concrete mix proportion is potential for lowering cost of construction projects. It will enhance indigenous concrete technology for transformation of national economy; and it will promote sustainable infrastructure development in Nigeria.

II. MATERIALS AND METHODOLOGY

Sample Collection and Preparation

Oyster Shell

The oyster shell was obtained from Kaa River, Khana Local Government Area. The aggregates were purchased at mummy-X Centre, Bori, Khana Local Government Area. Both materials were transported to Civil Engineering concrete laboratory, Ken Saro-Wiwa Polytechnic, Bori. The cement of grade 42.5 was purchased at Civil Engineering materials centre, Bori. The aggregates were washed, dried and the foreign materials were removed that will impede the accuracy of the experiments.

Experimental Procedure

Sieve Analysis:

The shell was crushed and incinerated at the temperature of 500^{o}C to obtain the pozzolanic properties of the oyster shell. It was further crushed manually after incineration into a powder form using a 2" thick steel plate and 8" x 8" cast steel tamping tools. It was sieved through 63microns (0.95mm). The shaker shakes the column usually for some fixed amount of time. The material on each sieve was weighed to give the percentage retained. The size of average particles on each sieve was analyzed to obtain the results of the test which was used to describe the properties of the aggregates.

Mix Proportions and Production of the Fresh ConcreteCubes

This was carried out on cube size of 150mm×150mm×150mm. The mixing of concrete was by hand/shovel. Cement and fine aggregate were mixed on a water tight non-absorbent platform until the mixture was thoroughly blended and of uniform colour. Coarse aggregate was added and mixed uniformly. Water was added and mixed thoroughly until the concrete appeared to be homogeneous and of the desired consistency. Concrete were filled in oiled moulds in layers approximately 50mm thick. It was compacted with tampering rod for 25strokes per layer. The top surface was levelled and smoothened. Control samples were produced (i.e, 0% replacement). The samples were cured in water for 7, 14 and 28days. This process was repeated with partially replaced concrete.

Concrete with Incinerated Oyster Shell

Compressive strength of concrete were produced by replacing the Portland Limestone Cement (PLC) with incinerated oyster shell (i.e. 10% and 20%) replacements. Each mixed were compacted using 4KN tamping rod (compaction rod) at three different layers. The cubes were allowed to set after 24hrs from the production time under laboratory condition ($27^{o} – 37^{o}$C) in the concrete laboratory Services.The cubes were cured for 7, 14, and 28days. The cubes were removed and transported to the concrete laboratory services for crushing. It was crushed. The physical properties of the samples were tested and compressive strength were obtained after been crushed.

Chemical Analysis

The burnt shell was analysed to determine their chemical composition in accordance with Nigeria industrial standard (NIS) method. 0.4g and 20.0g of the burnt oyster shells were poured into a grinding machine. Stearic acid was filled half in the cup. The top of the cup was carefully inserted into the pellet making machine (Herzog pressing machine). The pellet produced was them placed in the cement x-ray spectrophotometer. It was programmed with portland limestone cement and the start key was clicked so that within 2-3minutes the results were obtained.

Slump test:

This is an empirical test that measures the workability of concrete. It was carried out using Abrams cone. The cone was placed on a hard non- absorbent surface, filled with concrete in three layers. The concrete was tamped 25 times with tampering rod in each layer. At the end of the third layer, concrete was struck off, flushed to the top of the cone. The cone was carefully lifted vertically upwards so as not to disturb the concrete cone. The concrete cone subsidence is termed as slump and was measured in millimeter.

Compressive Strength Test

The compressive test was carried out in order to determine the compressive strength of the samples, which was done in accordance with BS method. The cubes were removed from the curing tank at the end of the curing period (7, 14 and 28 days) and were weighed, before compressive strength were carried out. The test was carried out in the civil Engineering Department, Ken Saro-Wiwa Polytechnic, Bori.

$$\text{Stress} = \frac{\text{Load (KN)}}{\text{Area (mm}^2\text{)}} \quad 1$$

III. RESULTS AND DISCUSSION

Results

The cube compressive strength was conducted in accordance with BS 2000 specifications by crushing machine for different proportion of concrete mixed at the concrete Laboratory in Civil Engineering Department, School of Engineering Ken Saro Wiwa Polytechnic. For this project the concrete cubes of size 150mm x 150mm x 150mm were prepared. A total of 6 square cubes were cast for each mix with different 10 and 20 percentages replacement of cement with burnt oyster seashells to be tested at different days of curing. The data collected is outlined below. Tables below shows the labelling system adopted.

Sieve Analysis

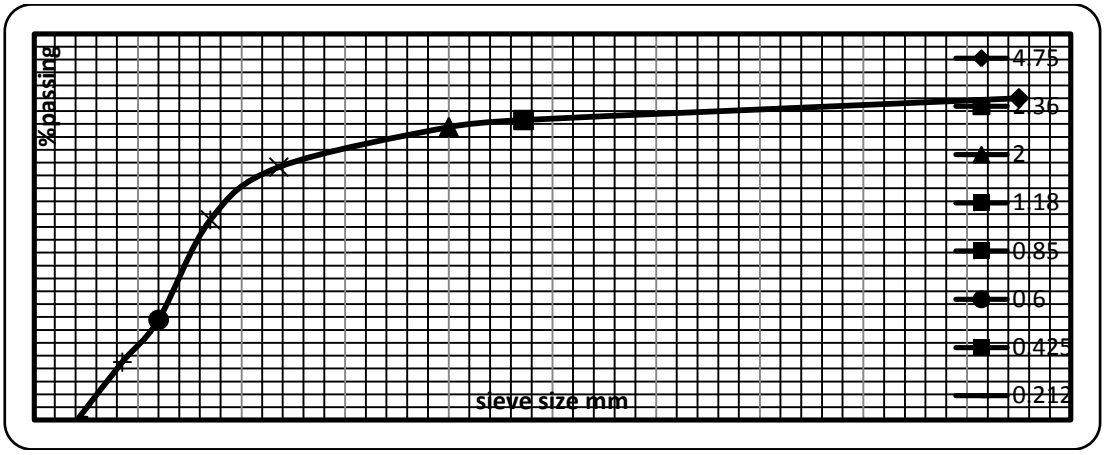

Figure1: Graph of sieve analysis of fine aggregate

Slump Test

Table 1: Result of slump test

Aggregates	Values of slump(mm)
Fresh concrete	18
Partial Replaced concrete	15

Data for Compressive strength

The compressive strengthof the different cube samples were determined using crushing machine values in KN and their readings are tabulated in the tables below.

Table 2: Compressive strength of normal mix 1: 2: 3

Days	**Numbers of cubes**	**Average compressive load (KN)**	**Mix proportion**
7	2	13.03	1:2:3
14	2	15.01	1:2:3
28	2	15.20	1:2:3

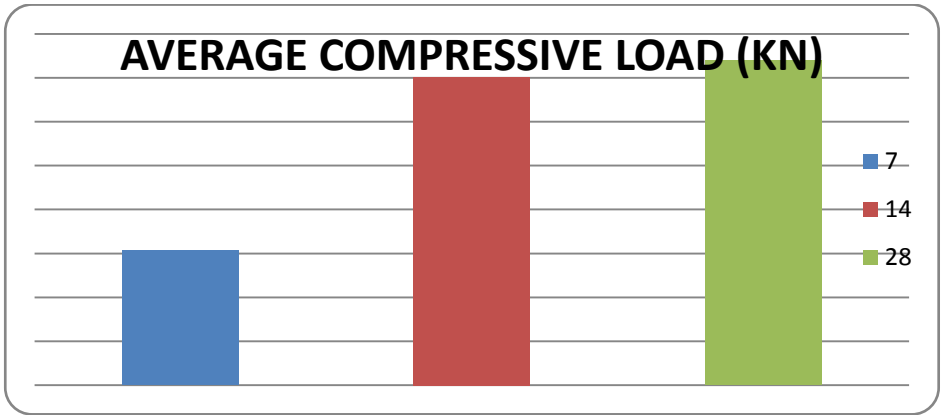

Figure 2: Graph of average compressive strength for normal mix

Table 3: Compressive strength of normal mix 1: 1.5:3

Days	Numbers of cubes	compressive load (KN)		Average compressive load(N/mm^2)	Mix proportion
7	2	17.02	12.67	15.84	1:1.5:3
14	2	15.68	18.82	17.25	1:1.5:3
28	2	23.46	23.97	23.72	1:1.5:3

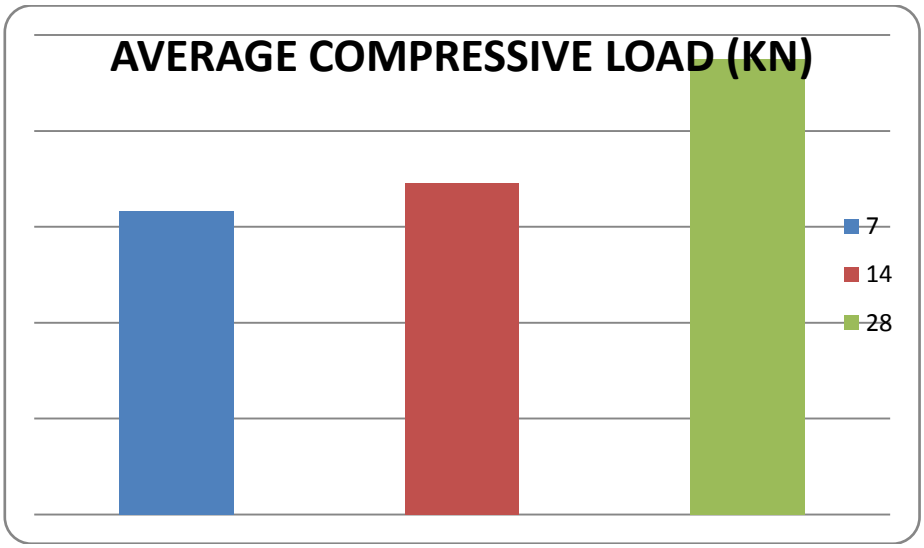

Figure 3: Graph of average compressive strength for normal mix

Table 4: Comparative of compressive strength of control, 10% and 20% burnt oyster shell for 1:1.5:3

Days	Number of cubes	Mix1: Control (N/mm^2)	Mix3:10% unburnt(N/mm^2)	Mix5:20% unburnt (N/mm^2)
7	2	15.20	15.83	16.93
14	2	13.03	13.83	15.65
28	2	15.01	18.32	18.49

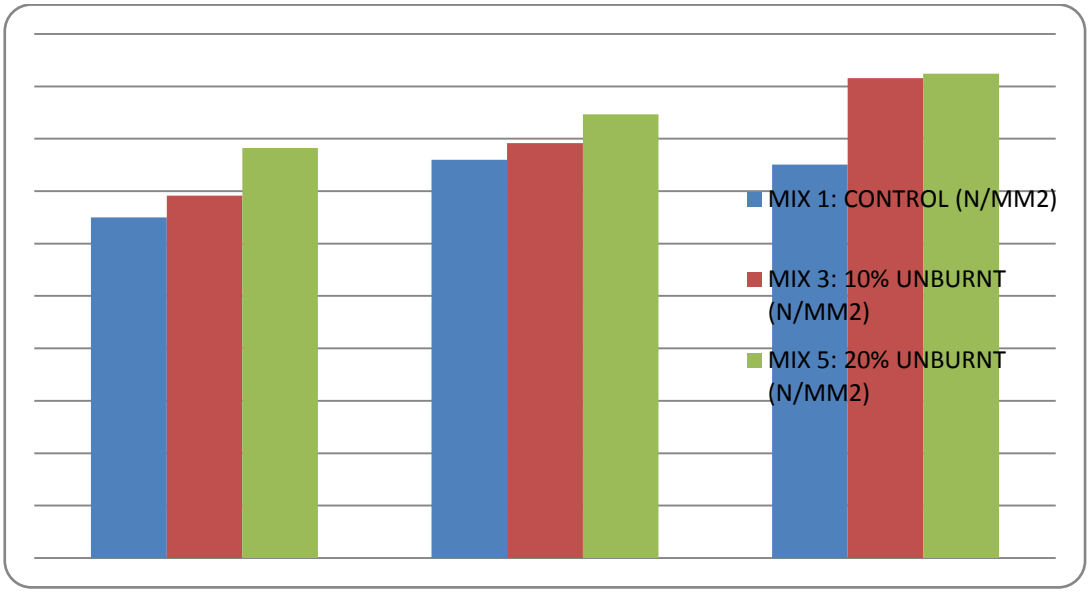

Figure 4: Comparative of compressive strength of control, 10% and 20% burnt pulverized oyster shell for 1:1.5:3

Table 5: Chemical composition PLC and the sea shells obtained

Chemical Composition	**PLC**	**oyster Shell**
SiO_2	20.06	13.26
Al_2O_3	5.85	8.79
Fe_2O_3	3.05	4.82
CaO	61.44	55.53
MgO	0.93	0.4
SO_3	2.71	0.18
K_2O	0.97	0.20
Na_2O	0.14	0.25
P_2O_5	0.17	0.05
MnO_3	0.20	0.07
TiO_2	0.28	0.05

IV. Discussion

The result of the compressive strength of the plain concrete cubes produced with the partial replacement of cement with burnt oyster seashells as shown in figures 1, 2, 3, and 4 for 1:2:3 and 1:1.5:3 and comparative results of replacement with control mix.

The figures show the plot of the compressive strength against number of days. The compressive strength of the various samples was compared with that of the control for different curing days. From the above results, the compressive strength of each concrete cubes for 10% and 20% burnt oyster shells varied for different curing days. It can be observed that most of the test samples possessed more strength than the control samples as the number of curing days increased especially Mix 2 (10% oyster sea shell burnt and cured for 28 days) while maintaining a mix ratio of 1:2:4.

V. CONCLUSION

Collectively, the following conclusions are drawn; for oyster seashell, it is observed from the bar chart that Mix 2 which incorporates 10% and 20% replacement of cement with burnt oyster sea shell possesses the higher strength compared to the control as the number of curing day increases. The development of seashell ash as partial replacement for cement could serve as a cement additive where the particle size will be the same or finer than that of cement. Concrete with partial replaced cement produces a better concrete in terms of strength, specific gravity, chemical composition. The highest compressive strength is achieved at 28days implying that the higher the period of curing, the higher the strength.

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