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Research Article

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Experimental Study of Coconut Shell as Coarse Aggregate in Concrete

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Abstract The increasing cost of building construction materials is a factor of enormous concern. For this reason, it becomes essential to carry out research on the material, which can reduce the cost of construction as well as increase the strength. This paper aim to observe the strength of concrete with different mix ratios of M7.5, M10, M15, and M20 grade concrete. The properties of concrete in the use of Coconut Shell Aggregate (CSA) of thickness size 10mm-13mm were studied. The observed outcome of compressive strength and density of concrete for M7.5, M10, M15, M20 grade concrete was by full replacement of coarse aggregate by CSA. 144 concrete cubes of sizes 150 x 150 x 150mm with different mix ratios of 1:4:8, 1:3:6, 1:2:4 and $1:1^{1/2}$:3 and water/cement ratio of 0.6 were cast and their compressive strength and density were evaluated at 7, 14, 28, 56 days. The concrete mix ratio 1:3:6 with CSA has the highest density of 1781.73kg/m^3 while the mix ratio $1:1^{1/2}$:3 with CSA and admixtures has the highest density of 1706Kg/m^3. The compressive strength of CSA at 7, 14, 28, 56 days with mix ratios of 1:4:8, 1:3:6, 1:2:4 and $1:1^{1/2}$:3 are (2.28N/mm^2, 3.10N/mm^2, 3.53N/mm^2, 2.83N/mm^2), (3.63N/mm^2, 4.45N/mm^2, 5.71N/mm^2, 4.96N/mm^2), (5.36N/mm^2, 6.47N/mm^2, 7.63N/mm^2, 5.98N/mm^2) and (7.18N/mm^2, 9.97N/mm^2, 14.15N/mm^2, 10.96N/mm^2) respectively. After 28 days of curing, mix ratio 1:4:8 and 1:3:6 in CSA attained the highest compressive strength of 3.53N/mm^2 and 5.71N/mm^2, while CSA with procrete-sp admixture attain the highest compressive strength of 4.37N/mm^2 and 6.07N/mm^2 at 28 days of curing. However, there was marginal change in strength of the concrete after 56days of curing for the nominal concrete while concretes with CSA slightly reduced in strength. The mix ratio $1:1^{1/2}$:3 in CSA attained the highest compressive strength of 14.15N/mm^2, while mix ratio $1:1^{1/2}$:3 in CSA with procrete-sp admixture attain the highest compressive strength of 15.47N/mm^2 at the 28 days of curing. This paper recommends CSA of mix ratios 1:4:8 and 1:3:6 for low density concrete and mix ratio $1:1^{1/2}$:3 for moderate concrete which correspond to the recommended concrete of (ASTM C 330-82a).

Keywords Coconut shell, Concrete, Cement, Aggregates, Partial

Introduction

The demand for concrete around the world today is extremely high and growing. In civil engineering construction, concrete is formed by the mixture of fine aggregate (sand), coarse aggregate, cement and water. The high demand of concrete in the construction using normal weight aggregates such as gravel and granite has considerably posed a very big environmental concern to humanity by reducing the natural stone deposits and this has damaged the environment thereby causing ecological imbalance, with alarming depletion rate through continued extraction. The prospect of a complete depletion of aggregate resources has rendered continued use of aggregates for construction unsustainable [1].

In examining this challenge, researchers throughout the world has been investigating ways of replacing aggregates to make construction sustainable and less expensive. Research addressing environmental and

sustainability issues in construction has generated lot of interest in the world [2]. This necessitates need to explore research for alternative suitable replacement materials that possess similar structural properties to substitute the natural stone. There is also demand to make concrete lighter and this has been the subject of study that has challenged scientists and engineers alike. The objective of the study was to observe the strength of concrete using coconut shell aggregate as coarse aggregate.

Methodology

Materials

Cement

The cement used in this study was Ordinary Portland Cement (OPC) from Dangote Cement Company Plc Ibese plant. This type-I cement complies strictly with [3].

Fine Aggregate

The fine aggregate used for this research was natural river sand quartzite dredged from river in Ikorodu, Lagos. The sand was well graded using standard sieves, flushed with water to remove fines, dirt and sun dried to be free from deleterious matters before use. It conforms to [4].

Coarse Aggregate

The material that passed through 12mm sieve was used to replace coarse aggregate with coconut shells. The retained material on 12mm sieve was discarded. It conforms to [4].

Portable Water

The water that was used throughout the tests was a drinking water and obtained from the public supply system in Yaba College of Technology, Yaba, Lagos. It appears clean and free from any visible impurities, conforming to [5].

Coconut Shell

The freshly discarded Coconut shells were collected from a local oil mill. The coconut shells were crushed using concrete hammers to a size such that it passes through a 20mm sieve and retained on 4.75mm sieve. Crushed shells were washed to remove fibers, mud, etc. from them. The washed shells are dried in sunlight for 2 days approximately at the temperature of 25^0C to 30^oC. The coconut shell was further broken into small chips manually using hammer and sieved through 13-16mm sieve.

Concrete Strengthener (Superplasticizer)

The superplasticizer used in this study was procrete-sp. Selection of 1.8%is based on the experiment carried out. It conforms to [6].

Compressive Strength Test

A total of 144 cubes of size 150 x 150 x 150mm with different mix ratios of 1:4:8, 1:3:6, 1:2:4 and $1:1^{1/2}$:3 were cast and demolded after 24 hours. Four mixes were prepared using standard mix ratios of 1:4:8, 1:3:6, 1:2:4, $1:1^{1/2}$:3for nominal concrete grades of M7.5, M10, M15, and M20 respectively. After design calculation, the super- plasticizer dosage of 1800 ml/100kg of cement was added to the mixes with w/c ratio of 0.60 throughout the experiment. The compressive strength was observed at ages of 7, 14 , 28 and 56 days and it conforms to [7].

Results and Discussions

Table 1: Concrete Grade Designation

Group	Concrete Grade	Mix Ratio	Characteristic Compressive Strength (N/mm^2)
Ordinary Concrete	M7.5	1: 4: 8	7.5 N/mm^2 (Blinding concrete)
	M10	1: 3: 6	10 N/mm^2 (Mass concrete)
	M15	1: 2: 4	15 N/mm^2
	M20	1: $1^{1/2}$: 3	20 N/mm^2
Standard Concrete	M25	1: 1: 2	25 N/mm^2
	M30	Design Mix	30 N/mm^2 (Reinforced concrete/precast)
	M35	Design Mix	35 N/mm^2 (Heavy Reinforced concrete/pre-cast)
	M40	Design Mix	40 N/mm^2 (Very heavy reinforced)
	M45	Design Mix	45 N/mm^2
	M50	Design Mix	50 N/mm^2

High Strength Concrete	M55	Design Mix	55 N/mm^2
	M60	Design Mix	60 N/mm^2
	M65	Design Mix	65 N/mm^2
	M70	Design Mix	70 N/mm^2

Table 2: Physical Test on Materials

S/N	Material	Test	Result
1	Cement	Density	2024.55kg/m^3
		Specific gravity	3.16
2	Fine Aggregate	Bulk density	2493.62kg/m^3
		Dry density	2363.83kg/m^3
		Moisture content	5.5%
		Free moisture content	4.5%
		Specific gravity	2.66
		Void age	0.41
		Water absorption	0.78
3	Coarse Aggregate	Moisture content	1.78%
		Bulk density	2367kg/m^3
		Specific gravity	2.76
		Water absorption	0.58
4	Coconut Shell 10mm- 13mm	Moisture content	14.29%
		Bulk density	905kg/m^3
		Specific gravity	1.48
		Water absorption	8.6%

As presented from figure 1 and 2: it was observed that the CSA improved with the addition of plasticizer in each mix. There were marginal increase in compressive strength of CSA which experience a slight decline in compressive strength at the 56 days of curing, this could be as a result of permeability void in CSA, since CSA has high water absorption, this may contribute to the weaken of the bonding between the CS and the matrix of the concrete.

In each of the control mix, it was observed that the CSA has high decrease of compressive strength having 0% presence of coarse aggregate (granite) which makes up the control mix. Mix ratio 1:4:8 and 1:3:6 in CSA attain the highest compressive strength of 3.53N/mm^2 and 5.71N/mm^2, while CSA with Procreate-SP attain the highest compressive strength of 4.37N/mm^2 and 6.07N/mm^2 at 28 days of curing which correspond to the recommended low density concrete of (ASTM C 330-82a). And the mix ratio of 1:2:4 and 1:1$^{1/2}$:3 attained the highest compressive strength of 7.46N/mm^2 and 14.15N/mm^2, while CSA with Procreate-SP attain the compressive strength of 8.21N/mm^2 and 15.47N/mm^2 at the 28 days of curing which correspond to the recommended moderate concrete of (ASTM C 330-82a).

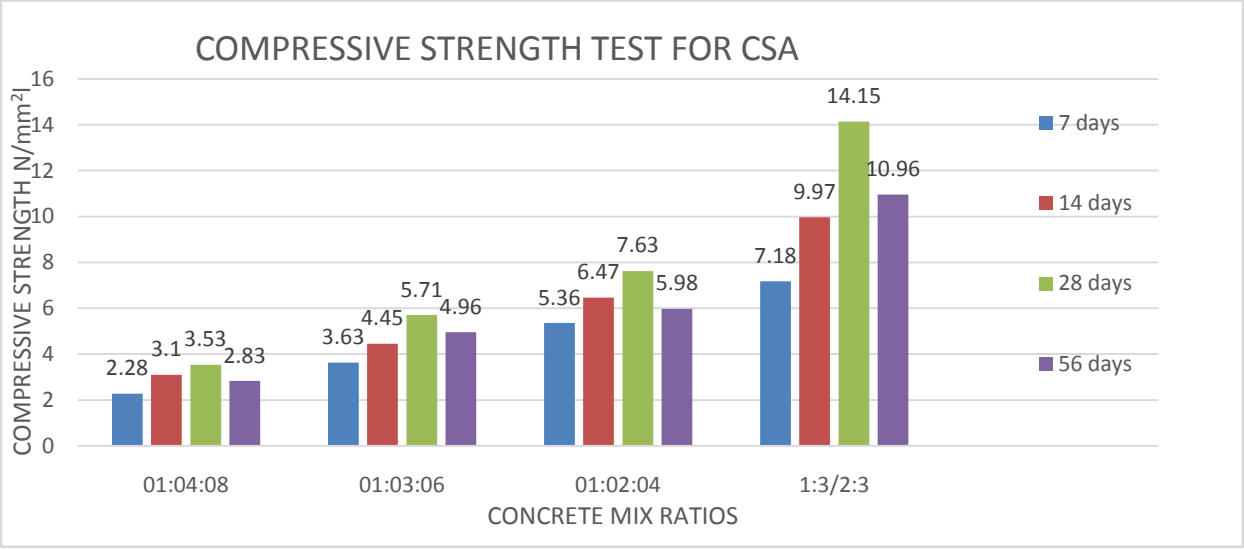

Figure 1: Variation of Compressive Strength against Mix Ratios for 7, 14, 28 and 56 days

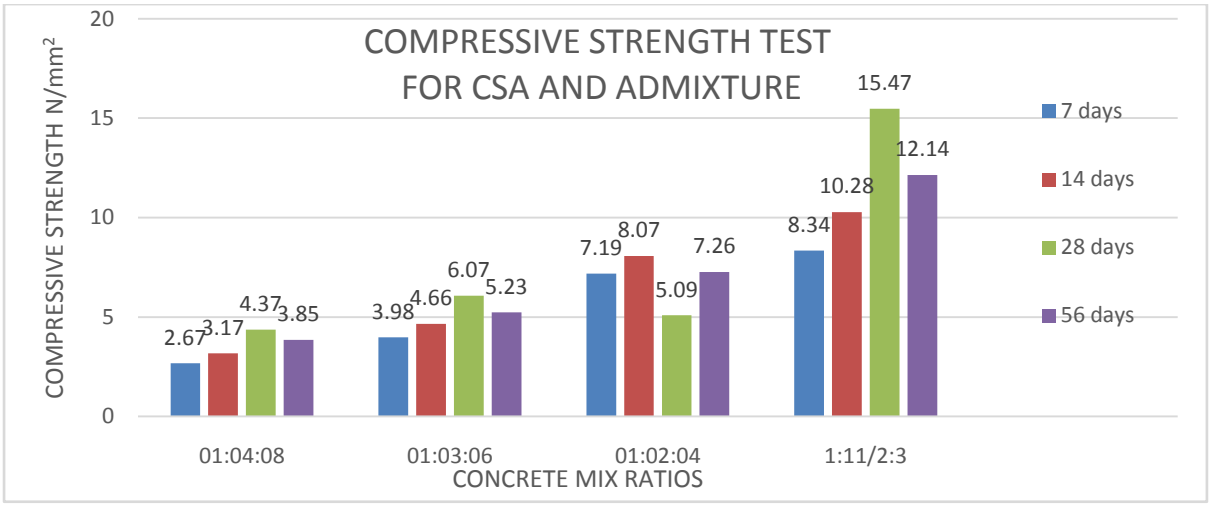

Figure 2: Variation of Compressive Strength against Mix Ratios for 7, 14, 28 and 56 days

As presented from figure 3 & 4: Mix ratio 1:3:6 in CSA attained the highest density of 1781.73Kg/m^3 while Mix ratio 1:1$^{1/2}$:3 in CSA and admixture attained the highest density of 1760.0Kg/m^3. The density of each mix grade of CSA with improved admixture increased in density as to compare with ordinary CSA. Because of the additional weight of the admixture there was consistency in increase in all the concrete mix grade. There were also marginal increase in weight for the CSA as a result of water presence of permeability void in the concrete.

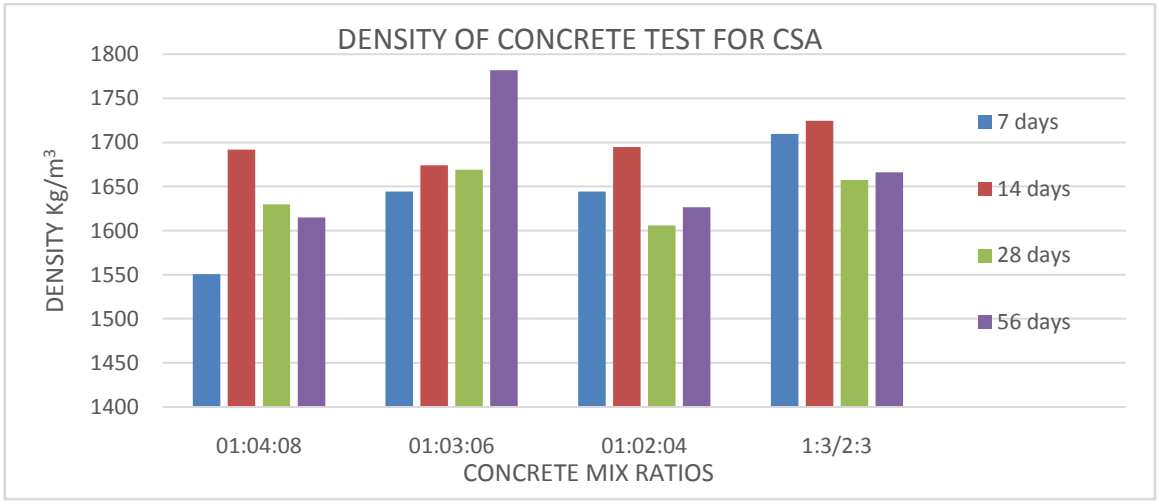

Figure 3: Variation of Compressive Strength against Mix Ratios for 7, 14, 28 and 56 days

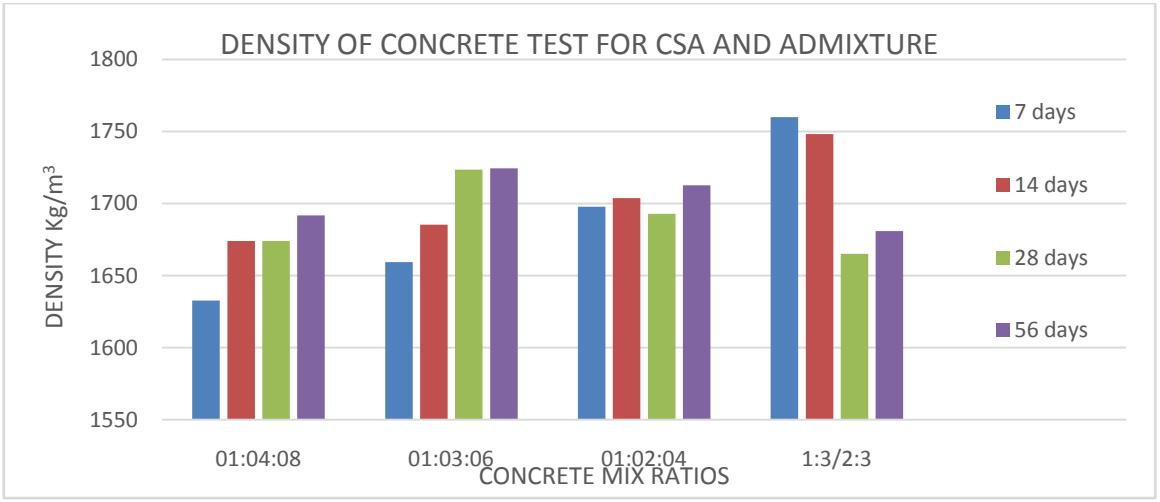

Figure 4: Variation of Compressive Strength against Mix Ratios for 7, 14, 28 and 56 days

Conclusion

In this study, the density and strength characteristics of concrete was investigated with the following conclusion:

i. Coconut shells can be used as partial replacement of crushed granite or other conventional aggregates in reinforced concrete construction.

ii. The particles with decreased size may avoid problems associated with shape and thus improve bonding between the aggregate particles and cement paste.

iii. Increased bond between the particles may increase surface area and may lead to increased water demand and may cause strength reduction.

iv. Coconut shell as aggregate in concrete will reduce the material cost in construction industry.

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