IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)
e-ISSN: 2278-1684,p-ISSN: 2320-334X, Volume 19, Issue 3 Ser. IV (May. – June. 2022), PP 34-37
www.iosrjournals.org

Application of Coconut Shell as a Partial Replacement of Coarse Aggregate in Concrete

OPARA HYGINUS EMEKA
Department Of Civil Engineering
Imo State University, Owerri.

Abstract
The need to reduce the high cost of concrete product in order to provide accommodation for the populace has led to intensified efforts at sourcing local materials that could be used as partial or complete replacement for granite coarse aggregate. This work investigated the comparative analysis of coconut shell as a partial replacement of granite aggregate in concrete production. Batching of the concrete ingredients were done by weight using concrete mix ratio of 1:1:5:3 and water/cement ratio of 0.55. The partial replacement of the granite aggregate with coconut shell of 0%, 10%, 20%, 30% and 40%. Two cubes for each percentage replacement of coconut shell making it a total of forty 150 x 150 x 150 mm concrete cubes. Slump test were done to determine the workability of the fresh concrete while compressive strength tests of the concrete were carried out at 7, 14, 21 and 28 days of curing respectively. The compressive strength at 28 days for 0%, 10%, 20%, 30% and 40% replacement of coconut shell were 32.03, 23.10, 21.20, 19.80 and 17.90. It is recommended that physical and mechanical properties of coconut shell can be classified as lightweight aggregate.

Keywords: *Coarse aggregate, coconut shell, compressive strength, granite.*

Date of Submission: 02-06-2022 Date of Acceptance: 15-06-2022

I. Introduction

Concrete is a composite material obtained by mixing cement, fine aggregate, coarse aggregate and water in specified proportions. The volume of concrete used in constructing buildings and civil engineering structures indicates that significant quantities of natural aggregate are mined by the construction industry. The coarse aggregate is commonly made from crushed granite used for building construction and other civil engineering structure. Other sources of coarse aggregate such as sand stone, local stone and river gravel are sometimes used in place of crushed granite for the production of concrete. The coarse aggregate constitutes more than fifty percent in every concrete mix design. This huge demand of natural aggregate raises a serious question about preservation of natural aggregate sources for sustainable development.

Therefore, the consumption of alternative waste material in place of natural aggregate in concrete production not only protects the environment but also makes concrete a sustainable and environment friendly construction material. Efforts to minimize construction costs have also necessitated the exploration of locally available aggregate substitute for concrete production.

Recent research on sustainable concrete construction has been directed towards using waste and by products of agricultural materials in concrete production. The literature has explained the effort of some researchers in using agricultural by products like oil palm shell, rice husk, corncob, molluse seashells and coconut shell. The application of wastes and by products will help to achieve sustainable concrete construction and natural resource preservation, energy consumption reduction, construction cost savings and efficient waste recycling.

This study is to assess the agricultural waste from the coconut shell as a partial replacement of coarse aggregate. The properties of coconut shell aggregate on the performance of concrete are reviewed and the prospects of coconut shell as an aggregate replacement material in concrete production.

II. Coconut Shell

Coconut being naturally available in nature and since its shells are non-biodegradable, they can be used readily in concrete which may fulfill almost all the qualities of the original form of concrete. The mesocarp is composed of a fiber called coir which has many traditional and commercial uses. Both the exocarp and the mesocarp make up the "Husk" of the coconut, while the endocarp makes up the hard coconut "Shell". Coconut shells are produced in a vast amount around tropical countries. Coconut shell has some characteristics like

fineness, modulus, toughness, low water absorption rate and specific gravity of about 1.16 that considers it as a good substitute of coarse aggregate.

2.1 TREATMENT AND PREPARATION

Coconut shell aggregate can be obtained by breaking and sieving shell particles to sizes. The fiber and husk on the shells were removed and then it was further broken into smaller chips manually using hammer and sieved through 12.5mm sieve. The material passing through the 12.5mm sieve was used to replace coarse aggregate with coconut shell. The material retained on 12.5mm were discarded.

It was necessary to break the coconut shell to the size of coarse aggregate. The use of unbroken coconut shells should be avoided because unbroken shells generate extra voids within the concrete matrix, negatively impacting the properties of concrete. Coconut shell were cleaned and treated to improve their performance as aggregate. The washed shell were subsequently aired and sun dried.

III. Materials And Method

3.1 MATERIALS

- Water: Portable water sourced from tap.
- Cement: Ordinary Portland cement of grade 42R used as a binder. The properties of the cement as stated by the manufacturer in Table 3.1
- Fine aggregate: the fine aggregate was sand dredged its specific gravity was 2.64 and the bulk density was 1560 kg/m3.
- Coarse aggregate: The coarse aggregate were procured from the dealers in Owerri mined from Isuikwuato in Abia State. The physical and mechanical properties of the coarse aggregate are as known on Table 3.2.
- Coconut Shell: The coconut shell collected from the dealers in Owerri were broken into pieces and then it was sun dried for five days at a temperature of approximately 25^{o} to 30^{o}c. The fiber and husk on the shells were removed and then it was further broken into small chips manually using hammer and sieved through 12.5mm sieve.

Table 3.1 Properties of Ordinary Portland Cement

Property	Value
Density	1.440 kg/m^3
Specific gravity	3.1
Initial setting time	120 min
Final setting time	300 min
Fineness	2%

Table 3.2 Physical and Mechanical Properties of Coarse Aggregate

Property	Value
Bulk Density	16650
Specific gravity	2.70
Los Angeles abrasion value (%)	10.86
Aggregate impact value%	29.27

3.2 METHODS

Physical properties of the aggregates as stated in Table 3.2 were tested. Sieve analysis of the aggregate were conducted in accordance with BS 882 (1983). Ordinary Portland Cement complying with NIS 444^{-1} (2003) was used as binder.

A concrete mix of 1:1.5:3 using water/cement ratio of 0.55 was prepared. The concrete were manually mixed on concrete pavement using a spade. The concrete ingredients were thoroughly mixed in a dry state, followed by the addition of water and further mixing to achieve consistency of crushed granite aggregate and partial replacement of the crushed granite aggregate with 10%, 20%, 30% and 40% coconut shell. Specimen moulds of 150mm cubes were cast and cured. Identification marks were made on each of the fresh concrete cubes. The cubes were removed from the moulds after 24 hours and then cured by complete immersion in a water tank. Eight cubes were prepared from each of the groups and two specimens were tested at 7 days, 14 days, 21 days and 28 days for each mix.

The specimen were tested in the laboratory using three properties of concrete. Slump, density and compressive strength. Slump test was conducted for the fresh concrete in accordance with BS 1881-102 (1983). Density and compressive strength tests of the hardened concrete cubes were carried out according to the requirements of BS 1881-114 (1983) and BS 1881 – 116 (1983) respectively.

The concrete mix proportions as shown in Table 3.3 were batched by weight. A total of 40 concrete cubes were used.

Table 3.3 Concrete Mix Proportions by Weight

S/N	No. of Cubes	Coconut Shell %	Cement Kg	Fine Aggregate Kg	Coarse Aggregate Kg	Coconut Shell Kg	Water Kg
1	8	0	11.782	17.673	35.345	0	6.480
2	8	10	11.782	17.673	31.810	3.535	6.480
3	8	20	11.782	17.673	28.276	7.069	6.480
4	8	30	1.782	17.673	24.741	10.604	6.480
5	8	40	11.782	17.673	21.207	14.138	6.480

IV. Results And Discussion

4.1 SLUMP

Slump values give an indication of the workability of the mixes. The results of the slum test are shown in Table 4.1. The results show that the slump of concrete decreases with increasing percentage content of the coconut shell. The mixes become less workable and more viscous as the percentage of the coconut shell increases. For the given water-cement ratio, the slump of the different samples fell within the range of 25 – 100mm, indicating medium workability Dhir and Jackson (1996).

Table 4.1 Slump Values of Different Percentage of Coconut Shell

Concrete	Value
0% Coconut Shell	74
10% Coconut Shell	65
20% Coconut Shell	58
30% Coconut Shell	51
40% Coconut Shell	43

4.2 DENSITY

Density is vital in structural concrete design because it significantly influences the dead load (self weight) of structural members. The density of concrete slightly reduces with the percentage inclusion of Coconut shell aggregate in the concrete mix. The reduction in concrete density can be attributed to entrapped air within the concrete matrix. Critical characteristics of Coconut Shell aggregate that influence concrete density are its lower specific gravity. The higher density observed for 100% granite concrete is attributed to the higher bulk density of crushed granite aggregate.

Concrete at 28 days containing coconut shell as a partial coarse aggregate at up to 40% replacement has more to 60% of its control density ie density at 0% replacement.

4.3 STRENGTH

Many properties of concrete are directly related to its strength, an increase in strength usually improves most other concrete characteristics. The main reasons for the reduction in the strength properties include higher water absorption, higher surface area, peculiar shape and presence of organic matter of the coconut shell. The higher surface area reduces the bond strength by increasing the available shell surface requiring cement coating. The data in the Table 4.2 shows the result of the compressive strength test of granite concrete and the partial replacement of granite concrete with Coconut Shell.

Table 4.2 Average Compressive Strength of concrete with various percentage of coconut shell.

Coarse Aggregate	Average Compressive Strength (N/mm^2)			
100% Granite Concrete	23.02	25.9	28.2	32.03
0% Coconut Shell	18.3	19.5	21.4	23.10
20% Coconut Shell	16.7	17.8	19.3	21.2
30% Coconut Shell	14.9	16.7	18.9	19.8
40% Coconut Shell	13.8	15.4	16.5	17.9

The results of the compressive strength test of granite concrete and the 10%, 20%, 30% and 40% partial replacement of Coconut Shell at 7, 14, 21 and 28 days as shown in Table 4.2 increased with age, with the 7 day concrete cube attaining the lowest compressive strength while the 28 day concrete cube had the highest compressive strength. Observation shows that concrete at 28 days is about 1.3 times as strong as the concrete at 7 days.

V. Conclusion And Recommendation

From the analysis carried out, the following conclusions can be drawn.

1. The slump of concrete decreases with increasing percentage of Coconut Shell as a partial replacement of granite in concrete.

2. The compressive strength of the concrete decreases with the higher content of the Coconut Shell.
3. Fresh concrete mix of partial replacement of granite aggregate with coconut shell gave lower workability than granite concrete.

VI. Recommendation

The physical and mechanical properties of Coconut Shell shows that it can be classified as light weight aggregate in concrete design.

References

[1]. BS 1881 - 102 (1983) Testing Concrete-Part 102: Method for determination of Slump. London: British Standard Institution.
[2]. BS 1881 - 102 (1983) Testing Concrete-Part 102: Method for determination of Density of Hardened Concrete. London British Standard Institution.
[3]. BS 1881 - 102 (1983) Testing Concrete-Part 102: Method for determination of Compressive Strength of Concrete Cubes, London: British Standards Institution.
[4]. Chander SP, Gunasekaran K, Satyanarayanan K.S Annaderai R. (2017) Study on some durability properties of Coconut Shell concrete with quarry dusk. European Journal of Environmental and Civil Engineering DOI:10:1080/19648189. 2017. 1418435.
[5]. Damodhara Reddy et al. experimental Analysis of the use of Coconut Shell as Coarse Aggregate "IOSR Journal of Mechanical and Civil Engineering Vol. 10, Issue 6.
[6]. Daniel Yam Osei (2013). Experimental Assessment on Coconut Shell as Aggregate in Concrete. International Journal of Engineering Science Invention Vol.2.
[7]. Dhir R.K, Jackson N Concrete in: Jackson N, Dhir RK editors. Civil Engineering Materials 5th ed Basingstoke; Palgare 1996; 169-298.
[8]. Echeta, C.B. Ikponwosa E.E and Fadipe A.O (2013). "Effect of Partial replacement of granite with washed gravel on the Characteristic Strength and Workability of Concrete" ARPN Journal of Engineering and Applied Sciences Vol. 8 No. 11 PP 954 – 959.
[9]. Ettu I.O, Ibearugbuluem O.M, Ezeh J.C, Anya U.C (2013). A reinvestigation of the prospects using Periwinkle Shell as partial replacement for granite in concrete. International Journal of Engineering Science Invention 2(3) 54-59.
[10]. Eziefula U.G. Onwuka D.O, Opara H.E (2021) Application of Molluse Seashell as Aggregate in Concrete BP International Dol: 10 9734/Dpi/nper/v3/3465f.
[11]. Eziefula U.G., Opara H.E, Nwosu O.U (2016). Properties of Sandstone Concrete and River Gravel concrete in Relation to Granite Concrete. Conference Proceedings 2016 Engineering Conference and Exhibition Akanu Ibiam Federal Polytechnic Uwana.
[12]. Eziefula U.G; Opara H.E., Eziefula B.I (2020) Strength of Concrete Produced with different sources of aggregates from selected parts of Abia and Imo States of Nigeria Jouranl of Engineering Design and Technology Vol. 18 Nos PP 1053-1061.
[13]. Eziefula U.G. Opara H.E, Anya C.U (2017). Mechanical Properties of Palm Kernel Shell Concrete in Comparison with Periwinkle Shell Concrete. Malaysia Journal of Civil Engineering 29(1): 1 – 14.
[14]. Neville AM, Brooks JJ (2010) Concrete Technology 2nd ed. Essex Pearson Education 442.
[15]. Sheffy, M.S (2012). Concrete Technology: Theory and practice 6th Ed. S. Chand, New Delhi.

OPARA HYGINUS EMEKA. "Application of Coconut Shell as a Partial Replacement of Coarse Aggregate in Concrete". *IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE),* 19(3), 2022, pp. 34-37.