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RESEARCH ARTICLE

USE OF COCONUT SHELL AS COARSE AGGREGATE IN LIGHTWEIGHT CONCRETE

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ABSTRACT

Wastes generated as a result of agricultural and industrial activities has become an environmental concern. In recent time global attention has been focused on environmental preservation, in an attempt to reduce environmental degradation, the use of agricultural and industrial wastes in concrete production has gained steady increase. Concrete being one of the major building materials that is used virtually in all aspects of construction, because it could be delivered to the job site, and be molded in situ or pre-cast to any form or shape. This makes it a material of choice in construction. This research work reports the investigation carried out to determine the use of coconut shell as an aggregate in light weight concrete. Concrete samples were produced with different mix ratios, to determine the best and economic proportions that will give acceptable compressive strengths. Concrete specimen were produced with coconut shell as coarse aggregate, ordinary river sand as fine aggregate and ordinary Portland cement as binders. Trial mixes which include (1:1:1, 1:1½:2, 1:2:2, 1:2½:3, 1:1½:3, 1:2:4, 1:2:3, 1:3:3, 1:3:4, 1:4:4) were done and it was observed that mix ratio 1:1:1 and 1:2:2 gave good consistency and workability with water cement ratio 0.5. The mix ratio 1:1:1; 1:2:2 gave compressive strength of 16N/mm^2 and 7.71N/mm^2 at 28day strength test respectively.

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INTRODUCTION

Concrete is the most commonly used structural material in the construction industry, its importance and the usage in the modern society cannot be ignored. Concrete is a product of mixing cement, fine aggregates, coarse aggregates and water in the right proportion. The water acts as the lubricating agents and it initiates chemical process that leads to hydration. The mixture when placed in modes or forms and allowed to cure hardens into a rock-like mass known as concrete (Sule, 2013). Advances in concrete technology have brought about the use of waste materials either from agricultural or industrial origin. The usage of agricultural wastes such as coconut shell as aggregate in concrete may lead to reduction in the depletion of ozone layer, because the energy hither to required in manufacturing process of concrete ingredients would have been conserved. It was reported by Mehta (2001) that "cement production, coarse aggregate mining, processing and transportation operations accounts for about 7% of the global loading of carbon dioxide into the atmosphere due to considerable amount of energy consumed, thereby affecting the ecology of the forested areas and river beds. In civil engineering practice and construction works, large volumes of coarse aggregates are usually used in the production of concrete. Gambhir (2005) reported that coarse aggregate constitutes about 75% to 85% of the concrete matrix. Hence the significance and relevance of coarse aggregate in concrete production in all areas of civil engineering practice and building construction cannot be ignored. Nigeria being a developing country is faced with inadequate provision of physical infrastructure; shelter and related amenities, which are typical factors of under development that need to be addressed through provision of alternative, cheap and affordable materials. In these areas development require the use of cement and other related materials such as coarse aggregate. Technologies which can provide means of upgrading shelter within the scope of the socio economic and cultural environment need to be developed (Elinwa, 2003). Currently, research efforts have been geared towards sourcing, development and the use of local alternative construction materials including the possibility of using some agricultural wastes as construction materials. Hence the focus of this research is to investigate the use of coconut shell as an aggregate in concrete through experimental investigation.

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MATERIALS AND METHODS

Materials

Cement

Ordinary Portland cement manufactured by Dangote company cement was used in this investigation. It was obtained from open market from accredited dear in Kaduna, Nigeria.

Fine aggregate

The fine aggregate (sand) was obtained from naturally occurring clean sand from River Kaduna, in Kawo area, located within latitude 10° 30′ N and longitude 7° 27′E.

Coconut Shell Aggregate

The coconut shell aggregate was obtained from the local hawkers of coconut (popularly called in Hausa "Kwakwa") in the central market area, Kaduna, located within latitude 10° 30′ N and longitude 7° 27′E.

Water

Water used for all the investigation was obtained from the laboratory and it is portable water, adequate for drinking. Thus, it is assumed good for making concrete.

Methods

The physical tests on OPC were carried out in accordance to Nigerian Industrial standard: NIS 11(1974); NIS 445(2003); NIS 446(2003); NIS 447(2003) and British standards, BS 4550 (1978) and BS 12 (1991) and EN 196-1: 1995 on dangote manufactured Portland cement used in this investigation. The results are summarized below in tables 2.1 to 2.4. The Dangote Portland cement conformed to the standards.

Soundness of Cement Paste

The soundness test for the brand of ordinary Portland cement used was conducted using the 'Le Chatelier' method of measuring expansion in accordance to NIS 447(2003) and BS 4550 (1978). The results of the soundness tests are presented in Table 2.1.

Setting times of cement paste

The tests for determination of initial and final setting times of the OPC used were done using Vicat apparatus in accordance with NIS 447 (2003) and BS4550 (1978). The results of the tests are presented in Table 2.2. The average results of the samples are as show in the table.

Fineness Test

The test was carried out in accordance with BS 12 (1991) and NIS 448, (2003). The test results are presented in table Table 2.3. The test was performed using the Blaine air permeability in accordance with NIS 11 1974 which provides an alternative test for fineness.

Table 1. Soundness test results of ordinary Portland cement used

OPC samples	Average Expansion (mm)	Total average Expansion
Specimen A	4.80	
Specimen B	4.75	4.78
Specimen C	4.80	

Table 2. Initial and Final setting time for the OPC used

Samples Of OPC	Average initial setting time (mins)	Overall average initial setting time (mins)	Average final setting time	Overall average initial setting time (mins)
Sample A	1hr. 42mins		3hrs. 02mins	
Sample B	1hr. 45mins		3hrs. 08mins	
Sample C	1hr. 48 mins	1hr. 45mins	3hrs.05mins	3hrs.05mins

Table 3. Fineness Test Result of OPC used (BS 12 1991 and NIS 448 2003)

OPC Samples	Specific surface area (m^2/Kg)	Average Specific surface area (m^2/Kg)
Sample A	658	
Sample B	659	658
Sample C	657	

Table 4. Fineness Test result of cement according to NIS 11 (1974)

Samples of OPC	% Passing sieve number 200(75µm)	Average % Passing sieve number 200(75µm)	% Retained on sieve number 200(75µm)	average % Retained on sieve number 200(75µm)
Sample A	96.13		3.87	
Sample B	96.15	96.09	3.85	3.91
Sample C	96.00		4.00	

Table 5. Particle size distribution – fine aggregate

Sieve size mm	5.00	3.35	2.36	1.18	0.60	0.30	0.15	0.075	Pan
% passing cumulative	99.23	96.72	90.18	81.16	60.16	25.99	17.28	5.20	0.00

Fine Aggregate Testing

The tests carried out gave 2.66 as specific gravity, 1535.67 Kg/m^3 bulk density and the particle size distribution analysis shows that it is within Zone 1. These tests were performed in accordance to BS 812 part 2, 1995, BS 812 part 101, 1990 and BS 812 part 103, 1989 respectively. The results are shown in Table 3.1. and figure

Coconut shell

It was sun dried for two months before being crushed in the quarry. The crushed Coconut shell material was later transported to the laboratory where they were thoroughly cleaned and washed, then allowed to dry under ambient temperature. The coconut shells were available in various shapes, such as curved, flaky, elongated, roughly parabolic and other irregular shapes as shown in Plate I and II. The sizes shown below were obtained before crushing. Plate II shows coconut shell aggregates after crushing from the quarry mill. The particle size distribution analysis of the coconut shell was carried out in accordance with BS 812 Part 101, 1984. Figure 2 shows the particle size distribution of coconut shell aggregate. While Table 3.2 is the physical characteristics of the coarse and coconut shell aggregates.

Table 6. Physical characteristics of the coarse and coco nut shell aggregates

Physical characteristics	Coarse aggregates	Coconut aggregates
Specific gravity	2.64	1.31
Bulk density Kg/m^3	1367.33	630.15
Impact value %	19.23	1.30
Aggregate crushing value %	25.67	1.16
Abrasion value %	27.67	2.23
Absorption capacity %	1.8	23.72
Elongation index %	8.78	26.69
Flakiness index %	36.89	86.12

Production Procedure

Prior to commencement of the trial mixes the coconut shells were pre soaked for 24 hrs and subsequently air dried under normal laboratory condition. This is because the coconut shell has high absorption capacity thereby reducing the available water for workability of the concrete. Ten trial mixes were conducted before arriving at a reasonable mix ratio. The trial mixes include the following (1:2:4, 1:2:3, 1:3:3, 1:1½:3, 1:2½:3, 1:3:4, 1:4:4, 1:1½:1, 1:1:1 and 1:2:2). Using mix ratio 1:2:4 as an example it means that one part of cement to two part of sand and to four part of coarse aggregate. After carrying out mix ratio 1:2:4, it was observed that there was segregation on removing the mould (See Plate III). Similarly mix ratio 1:2:3, 1:3:3, 1:1½:3, 1:2½:3, 1:3:4 and 1:4:4 failed on removing the mould after 24 hours. Plate IV shows cubes produced from mix ratio 1:3:3. However, cubes produced from mix ratio 1:1:1 and 1:2:2 retained their shape after de-molding. The compressive strength results at different age are shown in table 3.3. The water - cement ratio and aggregate - cement ratio of 0.5 and 2 were adopted for all the mixes. The coconut shell aggregate used was mixed at saturated surface dry condition based on 24hr submersion in portable water. The major experiment is to determine the best mix ratio using coconut shell aggregate concrete. The specimens were made in accordance with BS 1881 Part 108 (1983). The molded concrete cubes were given 24 hours to set before demoulding. They were then immersed into curing tank, to promote increase in strength, hydration, eliminate shrinkage and absorb heat of hydration until the age of test. The cubes prepared were cured for 3 days, 7 days, 14 days and 21 days and 28days. The cubes were weighed before testing and the densities of the cubes at different time of testing were measured. Prior to testing, the specimen were brought out of the curing tank, left inside in the open air for about 2 hours before crushing. The compressive strengths of the cubes were tested in accordance to BS 1881 Part 116 (1983) using universal testing machine. The results are shown in tables 3.3 for different size of aggregate for mix 1:1:1and 1:2:2

Table 7. Compressive strength results for the Coconut shell aggregate

Mix ratio	Aggregate size	Average compressive strength				
		3day	7day	14day	21day	28day
1:1:1	16mm	2.41	4.67	8.18	12.47	16.00
1:2:2	16mm	1.15	2.32	3.81	6.30	7.71

ANALYSIS AND DISCUSSION OF RESULTS

Ordinary Portland cement (OPC) Test

Cement Soundness

The test results are presented in table 2.1 the average expansion is 4.78 mm with the specification in BS 4450 and NIS 447 which recommends that average expansion should be less than or equal to 10mm. The cement samples satisfied the code of practice in terms of expansion.

Setting time of cement paste

The results of the setting time of the cement used were presented in table 2.2 the results are compared with the standard requirement which states that both initial and the final setting time should be greater than or equal to 45 minutes and less than or equal to 600 minutes respectively. From the results above the cement samples satisfied the code provision of setting time requirement. The lowest initial setting time being 1hr 2mins and the highest final setting time was 3hrs 08mins. Similarly, provisions of 45mins in European standards EN 196-1:1983 and EN 196-6 with respect to initial setting time was satisfied. Therefore, the Dangote cement used in the experiment satisfied the codes specification for ordinary Portland cement from the initial setting.

Cement Fineness

Fineness is an important property of cement and need to be carefully checked and controlled. The results of the test were presented in table 2.3 and 2.4 and compared with standard requirement specified in Bs 12 and NIS 448. The specific surface and the percentage retained on sieve 200 should be greater than or equal to 225mm2/Kg and less than 10% respectively. All the samples tested were satisfactory in terms of fineness.

Aggregate particle size distribution analysis

The sieve analysis is conducted to determine the particle size distribution in a sample of aggregate, often referred to as gradation.

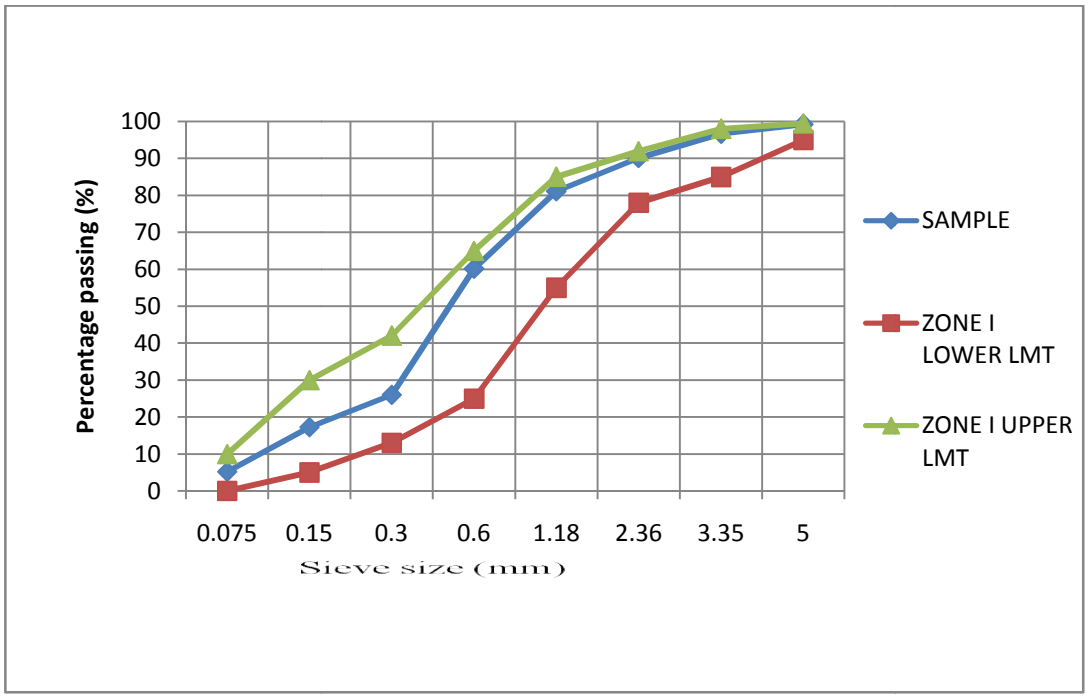

Figure 1. Particle size distribution for the fine aggregate

Plate I: Coconut shell aggregate before crushing

Plate II. Machine crushed Coconut shell aggregate

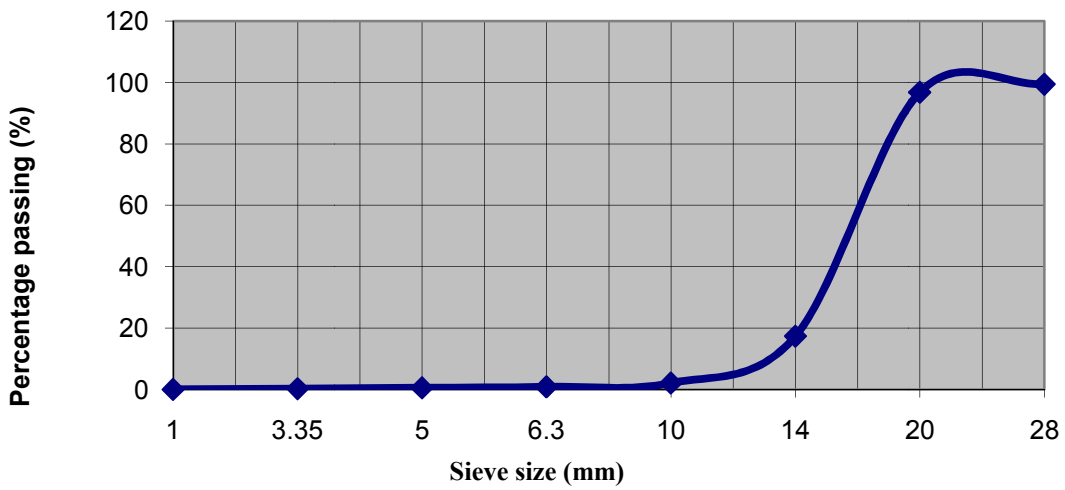

Figure 2: Particle distribution of Coconut shell aggregate

Table 6. Physical characteristics of the coarse and coco nut shell aggregates

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Plate III: Showing segregation of mix ratio 1:2:4

Plate IV: Showing the cubes from mix ratio 1:3:3

Plate V: Showing mix ratio 1:1:1 preparation in progress.

Plate VI: Showing specimen being casted into mould for mix ratio 1:1:1

Plate VII: Showing Coconut shell concrete cube for mix ratio 1:1:1 after test 28 day.

Plate VIII: Showing the cube produced for mix ratio 1:2:2

A good aggregate particle size distribution implies that a sample of aggregates contains all standard fractions. That is aggregate in required proportion, such that the sample contains minimum voids. The essence of particle size distribution analysis is to have well graded aggregate which have direct influence on producing workable concrete.

Fine aggregate particle size distribution analysis

The particle size distribution test result for fine aggregates is presented in table 3.13 of chapter three. This was carried out in accordance with BS 812: Part 103, 1989. The particle size distribution graph is shown in figure 4.1. This shows that the fine aggregate is in zone 2. The sand is also uniformly graded

Coconut shell aggregate particle size distribution

The particle size distribution analysis was carried to ensure that the resulting concrete is workable, since good grading of aggregates is one of the factors in producing good concrete. The results are shown in table 3.15 of chapter 3, while the graph showing the percentage passing against the various sieve sizes is shown in figure 4.3. The single aggregate size used in the analysis is reflected, as the highest percentage of the aggregate passing fell between size 14-20mm.

Compressive strength test results

The compressive strength test results of coconut shell aggregate concrete produced from the sizes of coconut shell aggregates 16mm and different mix ratios (1:1:1 and 1:2:2) are presented in table 7.

Compressive strength test results of coconut shell aggregate (size 16mm) with mix ratio 1:1:1

The results of the compressive strength test for coconut shell aggregate size 16mm is presented in table 7. The result shows minimum of 2.41N/mm^2 and maximum of 16.00N/mm^2 compressive strength development for 3day and 28day respectively. This result is an indication that the aggregate nominal size 16mm produces the highest compressive strength development as the age and curing continued.

Compressive strength test results of coconut shell aggregate (size 16mm) with mix ratio 1:2:2

The results of the compressive strength test for coconut shell aggregate size 16mm is presented in table 7.The result shows minimum of 1.15N/mm^2 and maximum of 7.71.00N/mm^2 compressive strength development for 3day and 28day respectively. This result indicates that mix ratio 1:1:1 produced higher compressive strength development as the age and curing continued.

Conclusion and Recommendation

Conclusion

The study of the properties of coconut shell aggregate concrete has been carried out through experimental investigation. The experimental results indicate that coconut shell has good potential as coarse aggregate in lightweight concrete. Therefore, based on investigation the following conclusion can be drawn:

i. The compressive strength of the coconut aggregate concrete shows sensitivity to the size of coco nut aggregate used. The concrete cubes produced from 16mm aggregate size gave high compressive strength.
ii. The compressive strength of coconut shell aggregate concrete at 28 day test was 16N/mm^2 which satisfied the requirement of lightweight concrete.
iii. The coconut shell aggregate concrete has a density ranging from 1542 Kg/m^3 to 1782Kg/m^3 which is within the lightweight concrete density.

Recommendations

Based on the scope and the results of this research the following are the recommendation for further investigation.

i. A study of the shrinkage characteristics of Coconut shell concrete is recommended.
ii. A long term durability study of Coconut shell concrete should be investigated.
iii. There is the need to study the permeability of coconut shell concrete.
iv. The study of the development of the micro structure of the coconut shell concrete is important in predicting the long term behavior.
v. The use of coconut shell aggregate should be encourage in the locality where it is in abundance to enhance environmental cleanliness.

REFERENCES

Abdul Awal, A.S.M., and Hussin, W. 1996. Properties of Fresh and Hardened Concrete containing Palm Oil Fuel ash. *Proceeding 3rd Asia-Pacific Conference on Structures Engineering and Construction* (ASPEC '96) pp. 359-367.

Adewuyi A. P. and B. F. Ola 2003. Application of Water works stage as partial

Agunsoye J.O., Talabi, S.I and Sanni O.S. 2012. Study of mechanical Behaviour of coconut shell Reinforced Polymer Matrix composite. *Journal of minerals and materials characterization and Engineering,* 11(1): 774-779.

Alleman, J.E., and Berman, N.A. 1984. Constructive sludge management: Biobrick. *Journal of Environmental Engineering*, 110 (2): 301-311.

American Concrete Institute Committee 201 1977. *Guide to durable concrete*, Detroit, Michigan. Author

American Concrete Institute Committee 232 1994. ACI 116R, *ACI Materials Journal,* July-August, pp 411.

American Standard for Testing and Materials 1994. *Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete*, ASTM C 618-94. Author

Brady G. S. 1986. *Materials Hand Book.* McGraw-Hill, London, pp. 126.

British Standard Institution 12 1971. *Ordinary and rapid hardening Portland cement*. Author

British Standard Institution 1983. *Methods for mixing and sampling fresh concrete samples in the laboratory,* BS 1881, Part 125. Author

British Standards Institution 1983. *Method for Determination of Compressive Strength of Concrete Cubes*, BS 1881, Part 116, London. Author

British Standards Institution 1983. *Methods of Determination of Slump*, BS 1881, Part 102, London. Author

British Standards Institution 1984. *Testing aggregates - Guide to sampling and testing aggregates*, BS 812, Part 101. Author

British Standards Institution 1985. *Testing aggregates – Methods for determination of particle size distribution*-BS 812, Part 103, Section 103.1 Sieve tests. Author

British Standards Institution 1989. *Testing aggregates – Methods for sampling*, BS 812, Part 102. Author

British Standards Institution 1989. *Testing aggregates – Methods for Determination of particle shape* – Section 105.1 Flakiness index, BS 812-, Part 105.1. Author

British Standards Institution 1990. Testing aggregates – *Method for Determination of moisture content*, BS 812, Part 109. Author

British Standards Institution 1990. Testing aggregates – *Method for Determination of aggregate crushing value (AVC)*, BS 812, Part 110. Author

British Standards Institution 1990. Testing aggregates – *Method for Determination of aggregate impact value (AIV)*, BS 812, Part 112. Author

British Standards Institution 1990. Testing aggregates – *Method for Determination Of aggregate abrasion value BS 812, Part 113. Author*

British Standards Institution 1990. *Testing aggregates – Methods for Determination of particle shape* – Section 105.2 Elongation index of coarse aggregate, BS 812, Part 105.2. Author

British Standards Institution 1995. *Testing aggregates - Methods of Determination of density*, BS 812, Part 2. Author

British Standards Institution, 1975. *Sampling and Testing of Mineral Aggregates, Sands and Fillers*. BS 812, London. Author

Bunguant, B.K. and Mohammedbhai, G.T.G. 1990. A study of the potential use of mauritain bagasse ash in concrete. *African Journal of Science and Technology*, Series A. 8 (1):16-25.

Canadian Building Digest 1981. *Waste and by-product as concrete aggregate* CB0-215)

Chitharanjan N. 1988. Development of Aerocrete a New Lightweight High Strength Material. *The International Journal of Cement composites and Lightweight concrete,* 10: 27-38.

Delsye C.L.T, Abdul Mannan M.d and Kurkui J.V 2006. *Journal of Advances Concrete Technology*, 4 (3) PP: 1-10

Falade F 1992. The use of Palm Kernel Shells as Coarse Aggregate in Concrete. *Journal of Housing Residence,* 16(3): pp 213 –219.

Falade F. 1995. An Investigation of periwinkle shells as coarse aggregate in concrete. *Building and Environment,* 30(4): pp 573-577.

Gambhir, M.L 2004. *Concrete Technology*. Tata McGraw-Hill Publishing Ltd New Delhi, India.

George N.A and Vinayakrishnan 2002. Photoacoustic evaluation of the thermal diffusivity of Coconut shell. *Journal of Physics: Condensed Matter*, 14: 4509-4513.

Jackson, N. and Dhir R. K 1991. *Civil Engineering Materials.* Macmillan Education Ltd., Hong Kong.

Khanbilvardi, R., and Afshari, S. 1995. Sludge ash as fine aggregate for concrete Mix Journal of Environmental Engineering ASCE.121(9) : 633-638.

Khedr, A.S., and Abou-zeid, N.M. 1994. Characteristics of Silica-Fume Concrete. *Journal of Materials in Civil Engineering*, ASCE. 6: 357-375

Malhotra, V.M. 1999. *Role of Supplementary cementing materials in reducing greenhouse gas emissions*. Sheffield Academic Press, Sheffield.

Mannan, M.A and Ganapathy 2001. Long term strengths of concrete with Oil palm shell as coarse aggregate. *Cement and concrete Research*.

Mannan, M.A and Ganapathy C. 2004. Concrete from agricultural waste oil palm shell (OPS). *Building and Environment Journal.*

Mannan, M.A and Ganapathy. C. 2002. Engineering properties of Concrete with oil palm shell as coarse aggregate. *Construction and Building materials.*

Mehta, P. K. 2001. Reducing the environmental impact of concrete. *Concrete International*.

Menon D. and Pillai SU 1987. Utilization of coconut industry by products in Energy efficient Building Systems: Proceedings of the National seminar on environment. Institution of Engineers (India) April 1987.

Naik T. R. 2002. Greener concrete using recycled materials. *Concrete International.*

Ndoke P. N. 2006. Performance of Palm kernel shells as a partial replacement for coarse aggregate in asphalt concrete. *Leonardo Electronic Journal of Practice and Technologies* 5(6): 145-152.

Nuhu-Koko M.K. 1999. The use of palm kernel shell as Coarse Aggregates for coarse. Paper presents at 21st annual conference of material testing control and research, Federal Ministry of Works, Lagos, Nigeria, 199, 20PP.

Olugbenga, O.A., Opeyemi, S. O and Olakanmi, 2011. Potentials of coconut shell and husk ash on the geotechnical properties of lateritic soil for road works *International Journal of Engineering and Technology,* 3(2) :87-94

Omange G.N. 2001. Palm kernel shells as road building materials. *Nigerian Society of Engineers Technical Transaction*, 36(1)

Owen P.L. 1993. Lightweight aggregate for structural, structural lightweight aggregate concrete, edited by J. L. Clark, Blackie Academic and Professional London.

Owen, P.L. 1985. Effect of temperature rise and fall on the strength and permeability of concrete made with and without fly ash. *American Society for Testing Materials,* pp134-169.

Payam, S., Jumaat, M.Z and Mahumd, H. 2010. Mix Design and Mechnical properties of oil palm shell light weight aggregate concrete: A review. *International Journal of the Physical Science,* 5 (14): 2127- 2134. Research National-Research Council Canada; Heyden and Son Ltd, pp 200-208.

Ramaswamy, S.D., Murthy, C.K. and Nagaraj, T.S. 1983. Use of waste materials and industrial by-products in concrete construction. In: *Concrete Technology and Design*. pp 137-172.

Replacement for cement in concrete production. *Science Focus Journal,* 10 (1) 123-130.

Sapuan S.M and Harimi M 2003. Mechanical properties of Epoxy/ coconut shell filler particle composites. *The Avabian Journal for Science and Engineering,* 28(2B)

Satish C 1996. "Waste materials used in concrete" ISBN 0815513933/9780815513933., 2005. *Engineering, Environmental* Engineering, ASCE. 113(2) : 278-284.

Shell ash for potential utilization in matrix composites for automotive application. *International journal of Engineering science and technology* (IJEST) 4(30)

Shetty, M.S. 2006. Concrete Technology (Theory and practice), First Multi colour illustrative revised Edition 2005: Rajendra Ravindra Printers Ltd.

Singhapura, S.D.K.G, Perera, M.A.P, Chathushka, P.G.S and Subashi, De Silva

Tay, J.H. 1990. Ash from oil palm waste as concrete material. American Society of Civil Engineers. (2): 94-105.

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