IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)
e-ISSN: 2278-1684,p-ISSN: 2320-334X, Volume 17, Issue 6 Ser. III (Nov. – Dec. 2020), PP 17-22
www.iosrjournals.org

Sustainable Concrete Using Periwinkle Shell As Coarse Aggregate – A Review

[1]Omisande Lawrence A. [2]Onugba Michael A.
[1]Department of Civil Engineering, Faculty of Engineering, The Federal Polytechnic Ilaro, Ogun state Nigeria
[2]Department of Civil Engineering, School of Engineering, The Federal Polytechnic Idah, Kogi state Nigeria

Abstract
In the present age, the demand for construction material is on a steady increase. Concrete the most widely used construction material is composed mainly of aggregate (fine and coarse), cement and water. The cost of this concrete ingredient is equally rising day by day. Recently researchers have paid so many attentions to waste that can fully or partially replace the conventional concrete ingredients without compromising the standard of concrete produced with convectional materials. This will not only produce an economic concrete but also a sustainable, affordable and environmental friendly concrete. Published works have shown a huge potential of using periwinkle shell an aquatic waste products generated from Periwinkles consumption found in many coastal communities worldwide as a replacement of coarse aggregate. A comprehensive outline of published literature on periwinkle the use of periwinkle as granite replacement in concrete is presented. The impact of periwinkle on characteristic properties of concrete such as workability, compressive strength, split tensile strength, bond strength, impact resistance and heat resistant have been presented.

Keyword*: Periwinkle, light-weight concrete, coarse aggregate, concrete*

Date of Submission: 27-11-2020 Date of Acceptance: 11-12-2020

I. Introduction

The overall importance of concrete in nearly all civil engineering practice and other numerous construction works cannot be overemphasized[1]. It is widely used in huge quantities almost everywhere mankind has need for infrastructure. The amount of concrete used worldwide supersedes other construction materials such as wood steel, glass, plastics, aluminum, and iron combined. Concrete is composed of about 70%-80% of coarse aggregate; hence the proportion of coarse aggregate is of great significance[2]. The rising growth in the construction industry has posed the likelihood of depletion of natural aggregates in the near future which would raise the cost of concrete material[3]. Owning to the insufficiency of these conventional construction materials such as granites, cement etc as required, and the local demand for these construction materials far exceeds the local supply resulting in a continuous increase in cost of construction project such as buildings, roads, pavements etc. in a developing country[17]. Currently, lots of waste and industrial by products materials regarded are being used to replace natural aggregates in concrete partially or fully and Ordinary Portland cement [32]. Research has shown that this waste possesses some properties that are suitable to produce concrete up to a certain limit. The waste possesses no commercial value and being locally available; its usage in concrete production reduces cost of concrete production[4], conserves natural resources and protects the environment [5]. Lots of these by-products are used as aggregate for the production of lightweight concrete[1]. Consequently, numerous studies have been carried out to determine optimum replacement in concrete which will not influence negatively the engineering properties of concrete. Some of these wastes include coconut shell, plastic, palm kernel shell, waste marble tiles and various sea shells. Periwinkles shells (PS) are aquatic waste products generated from Periwinkles consumption, it is found in many coastal communities worldwide, is a very strong, hard and brittle material (fig1)[6,7]. Periwinkles (*Nodilittorina radiata*) are small greenish-blue marine snails with spiral conical shell and round aperture [1]. There exist hundred species apiece of two genera of Periwinkles in Nigerian, radula (brackish water specie) and *Pachymelaniaaurita* (fresh water habitat) [33, 34]. The average winkle lives three years and grows to a shell height of 20 mm, but the largest recorded winkle grew to 52 mm.[6] PS are agricultural aquatic waste product and how to dispose of it is a problem[7].

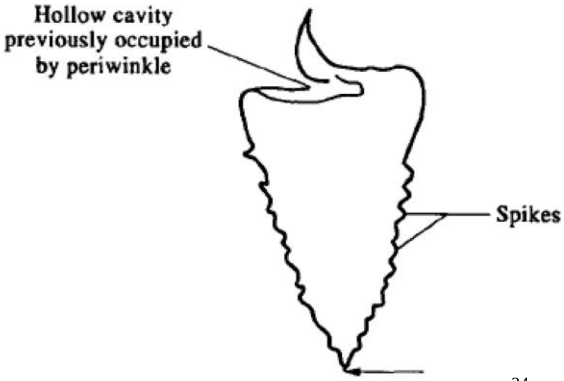

Figure 1: Appearance of the periwinkle shell[24].

They are common in the riverine areas and coastal regions of Nigeria where they are used for food, the people in this area consume the edible part as sea food and dispose of the shell as waste [6,7]. As a way of waste management, so many useful materials have been produced from these sea shells. These includes biomaterials such as chitin and chisotan[8], substitute for lime in glass manufacturing[9], formulation of fish feed as a source of calcium[10], calcium supplements in food industry [11], adsorbent media for removal of SO_2/NO_x[12] production of adsorbents for treatment of high COD[13] and lead[14]. The hard shells, which are considered as wastes usually posed environmental nuisance as large deposits have accumulated in many places over the years. They are now being considered as coarse aggregates in full or partial replacement for granite in concrete production [7]. However, the choice of locally available materials in concrete production depends on four main factors, such as strength, economy, compatibility, and availability[15]. Researchers have proved that, well-proportioned concrete mix should have qualities such as acceptable workability of freshly mixed concrete, durability, economy, strength and fire resistance[7]. This paper gives a review of the research findings on the use of periwinkles as replacement of coarse aggregate in concrete production.

II. Research Findings

In an analysis conducted by Adewuyi A. P. et al[1] on the utilization of PS as partial or full replacement of coarse aggregates in concrete 100:0, 75:25, 50:50, 25:75 and 0:100 replacement levels of granite to periwinkle shells. A total of three hundred concrete cubes of size 150 x 150 x 150mm were cast, tested and their strength properties were determined. Compressive strength tests showed 35.4% and 42.5% of the PS in replacement for granite was satisfactory with no compromise in compressive strength needs and savings of 14.8% and 17.5% for mix ratios 1:2:4 and 1:3:6 respectively. More analysis has shown the helpful properties of PS as coarse aggregates in concrete[16]. Granite was replaced with PS, with constant w/c ratio of 0.65 and concrete mix ratios of 1:1.5:3; 1:2:3; and 1:2.5: 3. The results revealed that the density of the concrete decrease with increase within the proportion of PS, from 2466.67 kg/m^3 for 25% PS replacement at a mix ratio of 1:1.5:3 to 2103.33 kg/m^3 for 75% PS replacement at a mix ratio of 1:2.5:3. The reduced densities of concrete produced can leads to lower self-weight of structure and this property is useful in areas where soils have comparatively low bearing capacities. Values of 28-day compressive strength ranged from 24.15 N/mm^2 for 75% replacement to 33.63 N/mm^2 at 25% replacement. These values almost equal utmost average value of 39.56 N/mm^2 obtained for 100% granite at 1:2:3 concrete mix ratio. This shows that lesser proportion replacements might be appropriate for structural purposes wherever concrete strengths of 35N/mm^2 are needed.

Similarly, Osarenmwinda et al. [17] investigated the prospect of PS as coarse aggregate in concrete production. The results showed that concretes created with 1:1:2, 1:2:3 and 1:2:4 concrete mixes provides concrete compressive strengths of 35.67 N/mm^2, 19.50 N/mm^2 and 19.83 N/mm^2 at 28 days in that order. These strength values met the ASTM-77 suggested minimum strength of 17N/mm^2 for structural light-weight weight concrete.

Oyedepo[27] in a research evaluated the properties of light-weight concrete using PS as coarse aggregate. In his study, 72 cubes of a 150 x 150 x 150 mm were cast with standard concrete mixture of 1:2:4 at varied percentages of 0%, 10%, 20%, 30%, 40%, 50% and 100% partial replacement of PS using water/cement ratio of 0.55. The strength characteristics of every cube were evaluated at the four ages of curing. The result showed that an optimum compressive strength of 16.79 N/mm^2 and 16.71 N/mm^2 may be obtained with the addition 20% and 30% partial replacement of coarse aggregate with PS in 28 days. These values are within 15-25 N/mm^2 and it's appropriate for light-weight concrete.

Dahunsi[18] examined the suitableness of PS, to be used as partial replacement of granite in concrete. Physical and mechanical properties of the shells and well-graded granite were determined and compared. Concrete cubes were cast using 1:0, 1:1, and 1:3, 3:1 and 0:1 proportion of PS and granite by weight, as coarse mixture. Concrete cubes with 100% PS alone were lighter but of lower compressive strengths compared to those with produced with different proportions of PS and granite combined. The 28-days density and compressive strength were 1824kg/m^3 and 12.12N/mm^2 respectively. Ameh[19] investigates the possible use of PS as an alternate replacement of coarse aggregate in concrete production. Granite was replaced with PS at 20%, 30%, 40% and 100% using different concrete mix of 1:1.5:3, 1:2:4 and 1:3:7 with w/c ratio of 0.65. The result indicates that the concrete developed good compressive strength at 28days curing age independent of the mix ratios. The suitableness of PS as a replacement of gravel in concrete production was investigated by Agbede et al.[20] . In his research concrete cubes were cast at coarse aggregate replaced at 1:0, 1:1, 1:3, 3:1 and 0:1 PS to gravel by weight. Concrete cubes with 100% PS were lighter and of lower compressive strengths compared to those with alternative periwinkle: gravel properties. The 28-day density and compressive strength of periwinkle were 1944 kg/m^3 and 13.05 N/mm^2 respectively. In this study, workability, density and compressive strength of periwinkle concrete improved with increasing percentage of gravel. The reduction within the density of concrete produced with PS concrete can be seen in table 1 and it justifies the explanation for its usage in coastal states as construction materials[6,20]. Such a large amount of states in coastal space of African nation (Niger delta, Nigeria) as an example have adopted its usage in concrete for over twenty years. Due to its abundance in these areas, its usage has absolutely influenced the value of concrete while not compromising the properties of concrete. Its usage during this space varies from building to road.

Table 1: Physical properties of PS

Properties	Authors		
	6	24	36,37
Size	-	-	10 – 20
Specific gravity	1.73	-	1.44 – 2.65
Density	619.90	694.44	517 - 1243
Water absorption	25	12.99	12.99
Moisture content	-	8.32	8.32
Impact value	65%	-	-
Durability	-	83	-
Finess modulus	-	-	12.99
Uniformity coefficient	-	1.23	-

Falade et al. [21], Ohimain, et al. [22] Osadebe et al [23] in their findings suggest a high prospect of using PS as coarse aggregate in concrete production. This affirms the suitableness of PS as partial replacement of granite in manufacturing concrete for concrete work[1,16,17,19,20,21,22,23]. Moreover, several researchers have discovered that integration of PS was accountable for decline of the compressive strength of the concrete principally at full granite replacement, and this was presumably a result of weak bonding between PS and matrix of cement [24], weak bonding of cement paste also as restricted strength of crushing of PS ingredients [25]. All the same, compressive strength of most 25MPa is realizable through complete substitution of coarse ingredients by PS in concrete. In manufacturing concrete beams composed of PS as coarse aggregate replacement, deflection of beams underneath flexural loading has been shown to be close to 25% bigger than that of ancient concrete because of low modulus of elasticity of PS concrete [25], whereas the strength of reinforced members in direct compression is low, flexural members possess satisfactory strength however with larger deformation than traditional gravel concrete. Hence, it has been recommended that designing PS concrete beam for strength and workability could be the same to plain concrete only if the alterations recommended are for light-weight concrete.

Performance of PS concrete at elevated temperature is studied by several researchers to evaluate the heat resistance of PS concrete to more justify its usage in concrete structures. In a research carried out by Falade [26] to assess the bond characteristics of the constituents of this concrete with increase in temperature, 432 concrete cubes (150mm×150mm×150mm) were cast. Concrete cube specimens were afterward subjected to heating between 50^{o}C/hr and 800^{o}C/hr in carbolite chamber kitchen appliance with regulated temperature up to 1000^{o}C. The bond between the concrete matrixes reduced with an increase in temperature. This is as result of the ease with which the components disintegrated as the temperature was increased. The temperature increase may have equally resulted in the deterioration of strength of the shells. This might be responsible for the prevalence of cracks and disintegration of the specimens during heating. The results revealed that with increase in temperature, a gradual loss in strength of the cubes were experienced. At temperature of 800^{o}C/hr, most specimens lost between 24% to 40% of their strength values [27]. Hence the usage of PS as coarse aggregates isn't suggested to be used in heat-resistant structures but where moderate temperatures of less than 300°C are projected.

Efforts have equally been made on the attainable use of PS with different waste that has made concrete with excellent workability and consistency in its fresh and hardened state, developed enough strength appropriate for its usage as coarse aggregate in concrete production. Such waste embody coconut shell, nut shell (PKS), plastic, rubber

In this regard, Oladiran et. al.[28] investigated the performance of nut shells (PKS) and PS as coarse aggregates in concrete. Forty cubes and forty cylinders were made with PKS and PS as replacement materials for granite. The result unconcealed that for all curing ages, PKS concrete have lower compressive strength and tensile strength than PS concrete. The compressive strength and tensile strength of the 28-day PKS with 100% replacement were 4.33 N/mm^2 and 3.68 N/mm^2 respectively; that of PS concrete at 100% replacement were 5.89 N/mm^2 and 4.95 N/mm^2 respectively; and control (0%) were 25.11 N/mm^2 and 11.74 N/mm^2 respectively. Although tensile strength isn't of utmost importance in the design of reinforced concrete, withal it's of significance in resisting cracking because of changes in wetness content or temperature.

Oyedepo et al [29] investigated the performance of PKS and PS as partial replacement for coarse aggregate in asphaltic concrete. A total of 36 samples were made by part substitution of coarse aggregate with PKS and PS at 0%, 10%, 20%, 30%, 40% and 50%. The Marshal stability values obtained was 2.33kN for 10% partial replacement with PS; 10% and 20% partial replacement with PKS has Marshall Stability values of 3.0kN and 2.2kN respectively, while 10%, 20% and 30% partial replacement with combination of PS and PKS has gave 3.22kN, 2.41kN and 2.21kN respectively, this satisfies the necessity for light-weight traffic road. Moreso, a flow value of 8.9 mm and 8.5 mm for 10% and 20% partial replacement with the mix of PS and PKS. This is often appropriate for light-weight traffic roads. Hence, 10 - 20% partial replacement of coarse aggregate with PS and PKS is used as different material in asphaltic concrete to scale back the price of road construction.

Gurikini et al [30] studied performance of concrete with partial replacement of coarse mixture with ocean shells and coconut shells. On the premise of the experimental studies applied on M30 grade concrete as partial replacement of coarse aggregates with ocean shells and coconut shells compressive strength of 100% (5% + 5%) of coconut shells (5%) and ocean shells (5%) increased, whereas the compressive strength of the concrete cubes on an increase of percentage replacement by additional 10% of ocean shells and coconut shells. Consequently 10% is desirable and suggested.

Sulaimon A.O et al [15], investigates the performance of Palm kernel shells (PKS) and PS as coarse aggregates in concrete at replacement levels of 0%, 25%, 50%, 75%, 100%. Forty cubes and forty cylinders were made at a mix ratio of 1:2:4 and 0.6 water/cement ratio. The results showed that, compressive and tensile strengths decrease as PKS and annotation content will increase. The result showed that for all curing ages, PKS concrete have lower compressive strength and tensile strength than PS concrete. During a similar analysis, Dahiru D. et al.[6] assessed the suitableness of PKS and PS part substitution fine and coarse aggregate at 0%, 25%, 50%, 75%, 100%. The results revealed that the strength properties (compressive and split tensile) of concrete made with partial or full replacement of fine and coarse aggregates with PKS and PS, reduced with an increase in the amount of PKS and PS. The reason behind the decline in strength is as a result of PKS incapability of manufacturing concrete with a compressive strength above 30N/mm^2 [19].

III. Discussion

Bulk Density

The densities of concrete produced with PS partially replacing granite have values less than 2400 kg/m^3 [6]. The reduced densities of concrete produced can leads to lower self-weight of structure and this property is useful in areas where soils have comparatively low bearing capacities. This property gives greater advantages as it can greatly reduce the time of construction thereby increasing the speed of construction as a result of the ease at which it can be handled.

Compressive strength

Table 2: Summary of the effect of PS on compressive strength of concrete

Author	Type Of Replacement	Control Sample (MPa)		Optimum Replacement	Compressive Strength (MPa)	
		7 Days	28days		7 Days	28days
6	Coarse	8.65	20	25%	9.67	18.50
31	Coarse	20.51	24.98	30%	15.5	21.1
24	Coarse	10.67	17.78	10%	9.78	16.22
27	Coarse	10.10	22.15	20%	12.82	16.79
35	Coarse	-	-	20%	11.93	21.80
15	Coarse	17.00	25.11	25%	14.45	20.67

28	Coarse	17.11	25.10	25%	14.87	21.11
16	Coarse	32.4	39.56	25%	30.4	33.63
1	Coarse	26.02	16.96	25%	15.82	22.51

Table 2 show the compressive of strength of PS concrete for 7 and 28 day curing ages. In all the research reviewed, the strengths of the mixes with PS concrete are lower than those of control mixes. The reduction in strength values may be as a consequence of the rough surface of PS which may prevent good bond with granite surface[24] and high water absorption ability of the shells[6,31]. Moreso, as the replacement level of PS increases, the fraction of cement paste becomes inadequate effectively bond with granite [1,24]. The effect of PS will be more pronounced in mixtures with high aggregate/cement ratio than in those with lower aggregate/cement ratio [24]. Hence, it has been recommended that designing PS concrete beam for strength could be the same to plain concrete only if the alterations recommended are for light-weight concrete. The 25% replacement of granite with PS can be used for non-critical structural works such as lintel, low traffic foothpath etc.[1, 16,28,15,6].

Tensile strength

Table 3: Summary of the effect of PS on split tensile strength of concrete

Author	Type Of Replacement	Compressive Strength Control Sample		Optimum Replacement	Compressive Strength (MPa)	
		7 Days	28days		7 Days	28days
6	Coarse	0.43	0.80	25%	0.48	0.76
15	Coarse	6.23	11.74	25%	5.66	10.33
28	Coarse	6.19	11.80	25%	5.71	10.33

It can be observed in table 3 that as the percentage replacement of PS increases the tensile strength reduces. This implies an inverse relationship between the tensile strength and the amount of PS employed partially in concrete production[6].
Although tensile strength isn't of utmost importance in the design of reinforced concrete, it's of significance in resisting cracking because of changes in wetness content or temperature.[15]

Thermal Performance

The bond between the concrete matrixes reduced with an increase in temperature. This is as result of the ease with which the components disintegrated as the temperature was increased. The results revealed that with increase in temperature, a gradual loss in strength of the cubes were experienced[26,27]. Hence the usage of PS as coarse aggregates isn't suggested to be used in heat-resistant structures but where moderate temperatures of less than 300^{o}C are projected[27].

IV. Conclusion

From the review of the published literature carried out above it can be concluded that use of these wastes will not only solve their disposal problem but equally reduce the environmental menace caused by its disposal. To go for green construction, adoption of PS as coarse aggregates is a true choice, as PS produces light weight concrete and would without doubt help in reducing the cost construction and increase the speed of construction.

References

[1]. Adewuyi A. P. and Adegoke T. (2008). Exploratory Study of Periwinkle Shells as Coarse Aggregates in Concrete Works. Journal of Engineering and Applied Sciences. Vol. 3, No. 6.
[2]. Falade, F., Ikponmwosa, E.E., and Ojediran, N.I. (2010). Behavior of lightweight concrete containing periwinkle shell at elevated temperature. Journal of Engineering Science and Technology, 5(4), 379 – 390.
[3]. Muthusamy K. and Sabri N. A. (2012). Cockle Shell: A Potential Partial Coarse Aggregate Replacement in Concrete. International Journal of Science, Environment and Technology, Vol. 1, No 4, 260 – 267.
[4]. Chandra, S and Berntsson L. (2002). Lightweight Aggregate Concrete Science Technology and Application. Noyes publication, New York.
[5]. Osei, D.Y. and Jackson E.N. (2012).Experimental Study on Palm Kernel Shells as Coarse Aggregate in Concrete. International Journal of Science and Engineering Research, vol. 3, issue 8, pp.1-6.
[6]. Dahiru, D., Yusuf, U. S. and Paul, N. J. (2018). Characteristics of Concrete Produced With Periwinkle and Palm Kernel Shells as Aggregates. FUTY Journal of the Environment Vol. 12 No. 1.
[7]. Ukpaka C. P, Okochi G. I. Production of Cement from Mixture of Palm Kernel and Periwinkle Shell. Indian Journal of Engineering
[8]. Aghoha E.E.C., (2007). Biomaterials from Periwinkles shells: Composition and functional properties. Paper presented at the World Congress on Medical Physics and biomedical engineering, Aug. 27 to sept 1 COEX Seoul, Korea Imaging the future medicine.
[9]. Malu, S.P and G.A Bassey, (2003). Periwinkle (T. Fuscatus) shell as alternative source of lime for glass industry. Global J. Pure and Applied Sci., 9(4): 491 – 494. http://ajol.info/index.php/gjpas/article/view/16056

[10]. Oribhabor, B.J and E.J Ansa, (2006). Organic waste reclamation, recycling and re-use in integrated fish farming in the Niger Delta. Journal of Applied Science and Environment Management, 10 (3) 47 – 53.

[11]. Malu S.P Abara A.E Obochi G.O, Ita B.I and Edem C.A (2009). Analysis of Egeria raiata and Thais coronate shells asalternative source of calcium for food industry in Nigeria properties of Periwinkle Granite concrete Pak J. Nutr, 8(7): 965 – 969.

[12]. Jung, J.H. Yoo K.S, Kim H.G, Lee H.K and Shon B.H (2007). Reuse off waste Oyster shells as a SO_2/NO_x removal Absorbent. Journal of Industrial Engineering chemicals, 13(5): 512 – 517. http://www.cheric.org/PDF/JIEC/IE13/IE13-4-0512.pdf

[13]. Madmus M.A and Audu T.O., (2009). Periwinkle shell: Based granular activated carbon for treatment of chemical oxygen demand(COD) in industrial wastewater. The Canadian Journal of chemical engineering. 87(1): 69-77. http://www.interscience.wiley.com/cgi- bin/fulltext/122212698/PDFSTART.

[14]. Madmus M.A and Audu T.O., and Anyata B.U (2007). Removal of lead iron from industrial wastewater by activated carbon prepared from periwinkle shells (Typanotonusfuscatus). Turkish Journal of Engineering and Environmental Science. 31: 251 – 263. http://journals.tubitak.gov.tr/engineering/issues/muh-07-31/muh-31-4-6-0703- 2.pdf.

[15]. Sulaiman A.O and Olatunde O.A. (2019**).** O.A. Study On The Use Of Palm Kernel Shell And Periwinkle Shell As Coarse Aggregates In Concrete. International Journal of Engineering Applied Sciences and Technology. Vol. 4, Issue 3, ISSN No. 2455-2143, Pages 454-460.

[16]. Ettu L. O. Ibearugbulem O. M, Ezeh J. C, and Anya U. C (2013). A reinvestigation of the prospects of using periwinkle shell as partial replacement for granite in concrete. International Journal of Engineering Science Invention. Volume 2 Issue 3. PP.54-59.

[17]. Osarenmwinda, J. O. and A. O. Awaro (2009). The potential use of periwinkle shell as coarse aggregate for concrete. Advanced Materials Research, 62-64:39-43.Doi: 10,4028/www.Scientificnet/AMR.62-64.39.

[18]. Bamidele I. O. Dahunsi (2003). Properties of Periwinkle-Granite Concrete. Journal of Civil Engineering, JKUAT: 2002 8: 27-36. https://scinapse.io/papers/2003500609.

[19]. Ameh, Afuye, T., I., & Amusan (2016). Prospect of Lateritic Sand and Periwinkle Shell as Aggregates in Concrete.

[20]. https://www.semanticscholar.org/paper/Prospect-of- Lateritic- Sand-and-Periwinkle-Shell-as-Ameh Afuye/eaef2b64581a0bac63ec27864b8c4d99db905bd9.

[21]. Agbede I.O and Manasseh J. (2009). Suitability of Periwinkle Shell as Partial Replacement for River Gravel in Concrete. Leonardo Electronic Journal of Practices and Technologies. Issue 15, p. 59-66. http://lejpt.academicdirect.org.

[22]. Falade, F., and F. Tella (2002). Structural performance of lightweight reinforced beams containing periwinkle shells as coarse aggregate. Sustainable Concrete Construction—Proceedings of the international conference held at the University of Dundee, Scotland, UK on 9-11 September 2002, 695-702.

[23]. Ohimain, Elijah I., Sunday Bassey, and Dorcas D. S. Bawo (2009). Uses of seas shells for civil construction works in coastal Bayelsa State, Nigeria: A waste management perspective. Research Journal of Biological Sciences, 4(9): 1025-1031.

[24]. Osadebe, N. N., and O. M. Ibearugbulem (2009).Application of Scheffe's Simplex Model in Optimizing Compressive Strength of Periwinkle Shell Granite Concrete. The Heartland Engineer, 4 (1): 27 – 38.

[25]. Falade F. (1995). An investigation of periwinkle shells as coarse aggregate in concrete. Build Environ 1995; Vol. 30 (4) : 573–577. https://doi.org/10.1016/0360-1323(94)00057-y.

[26]. Orangun C.O. (1974). The suitability of periwinkle shells as coarse aggregate for structural concrete. Materiaux Et Constr 1974;7:341–6. https://doi.org/10.1007/bf02473845.

[27]. Falade F. ,. Ikponmwosa E.E, Ojediran N. I. (2010). Behaviour of Lightweight Concrete Containing Periwinkle Shells at Elevated Temperature. Journal of Engineering Science and Technology Vol. 5, No. 4 (2010) 379 – 390.

[28]. Oyedepo O.J (2016). Evaluation of the Properties of Lightweight Concrete Using Periwinkle Shells as a Partial Replacement for Coarse Aggregate. Journal of Applied Science and Environmental Management. Vol. 20 (3) 498-505. www.bioline.org.br/ja.

[29]. Oladiran, O. J., Simeon, D. R. and Olatunde, O. A. (2020). Investigating the Performance of Palm Kernel Shells and Periwinkle Shells as Coarse Aggregates in Concrete. Lautech Journal of Civil and Environmental Studies. Volume 4, Issue 1.

[30]. Oyedepo O.J and Olukanni E.O. (2015). Experimental investigation of the performance of palm kernel shell and periwinkle shell as partial replacement for coarse aggregate in asphaltic concrete. J. Build. Mater. Struct. 2: 33-40.

[31]. Gurikini L. and Krishna R. .(2014). Experimental Study on Performance of Concrete M30 with Partial Replacement of Coarse Aggregate with Sea Shells and Coconut Shells. International Journal of Engineering Research and Applications Vol. 4, Issue 8, pp.148-151.

[32]. Timothy S., Anthony N.E, Gideon O.B, and David O. O. (2016). The Study of Periwinkle Shells as Fine and Coarse Aggregate in Concrete Works. 3rd International Conference on African Development Issues (CU-ICADI 2016), 361 – 364.

[33]. Sourav G. and Moulik S.C. (2015). Use of Coconut Shell as an Aggregate in Concrete: a Review. International Journal of Scientific Engineering and Technology**.** Volume No.4 Issue No.9, pp: 476-477.

[34]. Uwadiae, R. E, Edokpayi, C.A, and Egonmwan, R. I. (2009). The Ecology and Natural Food Components of *Pachymelaniaaurita* MÜLLER (Gastropoda: Melaniidae) in a Coastal Lagoon. Report and Opinion.1(5).

[35]. Bukola, C; Adebayo-tayo, A; Onilude, A.A; Ogunjobi A; and Damilola, O. A. (2006).Bacteriological and Proximate Analysis of Periwinkles from Two Different Creeks in Nigeria. *World Applied Sciences Journal.*1 (2): 87-91.

[36]. *Afuye I.T, Ehiabhi T. O, and Godwin E.O* (2018). Effect of Curing Methods on the Characteristic Strength of Concrete With Lateritic Sand And Periwinkle Shell**.** *American Journal of Engineering Research (AJER)* Vol-7, Issue-1, pp-283-287.

[37]. Yang E-I, Kim M-Y, Park H-G, Yi S-T (2010). Effect of partial replacement of sand with dry oyster shell on the long-term performance of concrete. Constr. Build Mater; 24:758–65. https://doi.org/10.1016/j.conbuildmat.2009.10.032.

[38]. Yang E-I, Yi S-T, Leem Y-M. (2005). Effect of oyster shell substituted for fine aggregate on concrete characteristics: Part I. Fundamental properties. Cement Concr Res 35:2175–82. https://doi.org/10.1016/j.cemconres.2005.03.016.

L Omisande Lawrence A, et. al. "Sustainable Concrete Using Periwinkle Shell As Coarse Aggregate – A Review." *IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)*, 17(6), 2020, pp. 17-22.