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COMPRESSIVE AND FLEXURAL STRENGTH OF CONCRETE USING PERIWINKLE SHELL AS PARTIAL REPLACEMENT TO COARSE AGGREGATE

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ABSTRACT
Concrete has been identified over many decades as the most common and used material in the construction industries. Due to the increased in the patronage of concrete, problem of availability and high cost of constituent materials, safe weight of concrete, sourcing of aggregates and growing concern on the continuous distortion of the ecosystem. This research work focuses on the compressive and flexural strength of concrete using periwinkle shell as partial replacement to coarse aggregate. The physical and mechanical properties of sharp sand, granite and periwinkle shell were determined. Absolute volume method of mix design was used with the inclusion of four independent variables of water/cement ratio, total aggregate/cement ratio, coarse aggregate/total aggregate ratio and periwinkle shell/coarse aggregate ratio, and the Minitab software was used to generate the number of mixes for the work. A total of 204 each of concrete cubes of 150mm x 150mm x 150mm and concrete beams of 100mm x 100mm x 500mm were cast from the generated mixes, tested, and their physical and mechanical properties were determined. The analyses of the result were done and computations of compressive and flexural strengths were calculated. The results obtained for the 28th day compressive and flexural strengths range from 9.99-19.30 N/mm^2 and 6.25-11.13 N/mm^2 respectively. As obtained from experiment, the results from the mechanical properties test compiled with the requirement of structural and non structural lightweight concrete as stipulated in British Standard,BS 8110 :Part 2 :1985. Concrete mixes which gave compressive strengths greater than 17N/mm^2 can be used as structural lightweight concrete.

Keywords: Compressive strength, Flexural strength, Minitab software Mix ratio, Periwinkle shell-granite concrete.

1 INTRODUCTION

Concrete is one of the major building materials in civil engineering practice and construction works in Nigeria and most countries of the world. High demand for concrete materials which give rise to the need for research into locally available materials, and the conventional normal weight coarse aggregates needed for construction purposes are expensive. (Ede et al, 2014).

Over the years, quarry activities in sourcing for granite and gravel have greatly impacted the environment negatively due to continual distortion of the ecosystem and as periwinkle shell is becoming huge wastes disposed in the environment, efforts were made in the direction of waste management strategies which include performance of concrete using Periwinkle Shell as partial replacement to coarse aggregate. Periwinkles are commonly found in the lagoons and mudflats of the South West and Niger Delta (Olutoge et al, 2012). Several works have been done to utilise Periwinkle Shell as partial replacement to coarse aggregate but most of the work dwells on compressive strength and flexural strength of concrete. (Adewuyi and Adegoke, 2008), (Amaziah et al., 2013).

This research work therefore seeks to apply the Minitab software using Absolute volume method of mix design to develop new models for the prediction of the 28th day compressive and flexural strengths of periwinkle shell crushed stones (granite) concrete. The outcome of this research would generate data for Engineers in consultancy and construction outfit. These data would aid design by furnishing the compressive and flexural strengths of lightweight concrete for given mix composition, which in turn saves enormous time and effort expended in carrying out trial mixes. It will also help manage the enormous pollution generated by periwinkle shell through their use as a construction material for lightweight concrete production.

2 METHODOLOGY

2.1 MATERIALS

Five constituent materials were used in the laboratory to produce the prototype concrete cubes and beams measuring150mmx150mmx150mmand 100mmx100mmx500mm respectively. Other materials include Ordinary Portland cement, river sand, river gravel, periwinkle shell and water.

(i) The Ordinary Portland cement with properties conforming to BS EN 197-1:2000 was used in the Laboratory experiment.

(ii) The river sand used was obtained from Jere in Kaduna state. It has physical properties of 1619.921kg/m3, and 2.58 corresponding to its values of un- compacted bulk density, and specific gravity respectively. The river sand is uniformly graded in Figure 1.

(iii) The granite used in the experiment has a maximum size of 20mm. It has an un-compacted bulk density, water absorption, specific gravity, impact value and crushing value of 1630.698kg/m3, 1.83%, 2.79, 12.23% and 13.66% respectively.

(iv) The periwinkle shells which have a maximum size of 19mm were obtained from River state. It has physical and mechanical properties of 611.48kg/m3, 5.13%, 1.28, 36.38% and 33.28% which corresponds to the un-compacted bulk density, water absorption, specific gravity, impact value and crushing value respectively

(v) Potable water was used for the experiment during mixing and curing operation

2.2 METHOD

MIX DESIGN, CONCRETE MATERIALS BATCHING, MIXING, PLACING AND CURING OPERATIONS

MIX DESIGN

The concrete mix design was considered first by determining the requirements of the concrete. These requirements were taken into consideration in the Absolute Volume Mix Method of Concrete.
Water/Cement ratio = 0.4,0.5,0.6
Total aggregate/Cement ratio = 3.0,4.5,6.0
Coarse aggregate/Total aggregate ratio = 0.55,0.62,0.70
Periwinkle/Coarse aggregate ratio = 0.20,0.25,0.30
The concrete constituents are calculated for a cubic metre of concrete using equation 1

$$V_W+V_C+V_{FA}+V_{CA}+V_{AIR}=1(m^3) \qquad (1)$$

Where,
V_W = Volume of water
V_C = Volume of cement
V_{FA} = Volume of fine aggregate
V_{CA} = Volume of coarse aggregate
V_{AIR} = Volume of air

Also equation 2 is been generated from equation 1 when volume of air is taken as 0.02

$$\frac{W_W}{1000S.G_W} + \frac{W_C}{1000S.G_C} + \frac{W_{FA}}{1000S.G_{FA}} + \frac{W_{CA}}{1000S.G_{CA}} + \frac{W_{PS}}{1000S.G_{PS}} + 0.02 = 1 \qquad (2)$$

Where,
W_W = Weight of water
W_C = Weight of cement
W_{FA} = Weight of fine aggregate
W_{CA} = Weight of coarse aggregate (gravel)
W_{PS} = Weight of periwinkle shell

BATCHING

Batching in this experiment was done with a weighing balance of 50kg capacity using the mix ratios that were calculated using absolute volume method for a four component mixture with the aid of Microsoft Excel and as shown in Table 1.

Table 1: Actual Proportion of Mix Constituents in kg/m³ for Concrete Production

X1	X2	X3	X4	W_W	W_C	W_{FA}	W_{CA}	W_{PS}	Wgr
0.5	2.38	0.62	0.25	246.84	493.679	446.483	728.473	182.118	546.355
0.4	6	0.55	0.2	113.217	283.041	764.211	934.036	186.807	747.229
0.5	4.5	0.62	0.25	161.974	323.948	553.952	903.816	225.954	677.862
0.5	4.5	0.62	0.25	161.974	323.948	553.952	903.816	225.954	677.862
0.5	4.5	0.62	0.25	161.974	323.948	553.952	903.816	225.954	677.862
0.5	4.5	0.62	0.25	161.974	323.948	553.952	903.816	225.954	677.862
0.5	4.5	0.62	0.32	154.197	308.394	527.354	860.42	275.334	585.085
0.5	4.5	0.52	0.25	166.079	332.157	717.459	777.248	194.312	582.936
0.6	3	0.7	0.3	234.154	390.256	351.23	819.537	245.861	573.676
0.5	4.5	0.73	0.25	157.688	315.375	383.181	1036.01	259.002	777.005
0.4	3	0.55	0.3	176.669	441.674	596.259	728.762	218.628	510.133
0.4	6	0.7	0.2	109.596	273.991	493.184	1150.76	230.152	920.609
0.6	3	0.7	0.2	250.521	417.535	375.781	876.823	175.365	701.458
0.6	6	0.7	0.3	143.244	238.74	429.732	1002.71	300.812	701.895
0.64	4.5	0.62	0.25	198.157	309.62	529.45	863.839	215.96	647.879
0.4	3	0.55	0.2	187.566	468.916	633.037	773.711	154.742	618.969
0.4	3	0.7	0.3	169.611	424.027	381.624	890.457	267.137	623.32
0.6	3	0.55	0.3	243.092	405.154	546.958	668.504	200.551	467.953
0.4	3	0.7	0.2	182.571	456.427	410.785	958.497	191.699	766.798
0.6	6	0.55	0.3	149.992	249.987	674.965	824.957	247.487	577.47

0.5	4.5	0.62	0.25	161.974	323.948	553.952	903.816	225.954	677.862
0.5	4.5	0.62	0.25	161.974	323.948	553.952	903.816	225.954	677.862
0.5	4.5	0.62	0.18	170.577	341.155	583.375	951.822	171.328	780.494
0.5	4.5	0.62	0.25	161.974	323.948	553.952	903.816	225.954	677.862
0.5	6.62	0.62	0.25	120.534	241.068	606.429	989.438	247.359	742.078
0.36	4.5	0.62	0.25	122.28	339.668	580.832	947.673	236.918	710.755
0.6	6	0.7	0.2	155.689	259.482	467.067	1089.82	217.965	871.858
0.6	6	0.55	0.2	160.551	267.585	722.479	883.029	176.606	706.423
0.6	3	0.55	0.2	256.777	427.961	577.748	706.136	141.227	564.909
0.4	6	0.55	0.3	105.371	263.426	711.251	869.307	260.792	608.515
0.4	6	0.7	0.3	100.387	250.968	451.742	1054.06	316.219	737.845
CONTROL MIX DESIGN									
0.4	3	0.55	0.2	187.566	468.916	633.037	773.711	154.742	618.969
0.5	6.62	0.7	0.3	113.053	226.106	449.046	1047.77	314.332	733.442
0.64	6	0.73	0.25	156.381	244.345	395.838	1070.23	267.557	802.672

MIXING, PLACING AND CURING

Manual mixing was adopted with the aid of spade. The constituent materials were mixed thoroughly until homogeneity was attained. After mixing, the concrete was cast into steel moulds measuring 150x150x150mm and 500x100x100mm.

Six representative samples of concrete cubes and beams were cast for each mix ratio.

They were cured for 28 days in an open curing tank filled with potable water. The compressive strength of cubes was tested for 7 and 28days by using the compressive testing machine by applying the load at the rate of 30N/mm2 per minute.

The compressive strength is calculated using equation 3 and the results are shown in Table 6

$$\text{Compressive strength} = \frac{\text{Crushing load(N)}}{\text{Cross section area of concrete cube (mm}^2\text{)}} \quad (3)$$

150kN capacity hand operated flexural testing machined designed for third point loading was used to crush the cured concrete beams. Constant rate of loading was applied on the concrete beams until failure occurred.

The laboratory modulus of rupture or flexural strength of each beam was determined using equation 4 and the results are shown in Table 6

$$\text{Flexural strength} = \frac{3FL}{2wd^2}(\text{N/mm}^2) \quad (4)$$

For a three point test, the flexural strength (σ) can be calculated by using:

Where:

F is the maximum force applied

L is the length of the sample

w is the width of the sample

d is the depth of the sample

3 RESULT AND DISCUSSION

3.1 Physical and Mechanical Characterisation of Aggregates

The physical properties of aggregates are shown in Tables 2, 3, 4, and Figures 1 - 5. The results obtained are similar to those of many researchers stated here.

3.2 Sieve Analysis

Tables 2, 3, 4, and Figure 1 show the sizes of aggregates and the percentage passing of aggregates.

Table 2: Result of Sieve Analysis for Fine Aggregate (Sharp Sand)

Sieve size	Mass retained(g)	% mass retained	Cum.% mass retained	% passing
5.00mm	1.2	0.24	0.24	99.76
3.35mm	34.2	6.84	7.08	92.92
2.36mm	80.7	16.14	23.22	76.78
2.00mm	42.5	8.5	31.72	68.28
1.18mm	134.5	26.9	58.62	41.38
850µmm	74.7	14.94	73.56	26.44
600µmm	66.1	13.22	86.78	13.22
425µmm	35.7	7.14	93.92	6.08
300µmm	17.9	3.58	97.5	2.5
150µmm	10.6	2.12	99.62	0.38
75µmm	0.8	0.16	99.78	0.22
Pan	0.9	0.18	99.96	0.04

Table 3: Result of Sieve Analysis for Coarse Aggregate (Granite)

Sieve size	Mass retained(g)	% mass retained	Cum.% mass retained	% passing
28.00mm	0	0	0	100
20.00mm	297.7	29.77	29.77	70.23
14.00mm	454.6	45.46	75.23	24.77
10.00mm	189.5	18.95	94.18	5.82
6.30mm	53.1	5.31	99.49	0.51
5.00mm	0.8	0.08	99.57	0.43
Pan	1.9	0.19	99.76	0.24

Table 4: Result of Sieve Analysis Test for Coarse Aggregate (Periwinkle Shell)

Sieve size	Mass retained(g)	% mass retained	Cum.% mass retained	% passing
20.00mm	0	0	0	100
14.00mm	15.2	1.52	1.52	98.48
10.00mm	612.5	61.25	62.77	37.23
6.30mm	341.8	34.18	96.95	3.05
5.00mm	5	0.5	97.45	2.55
Pan	23.1	2.31	99.76	0.24

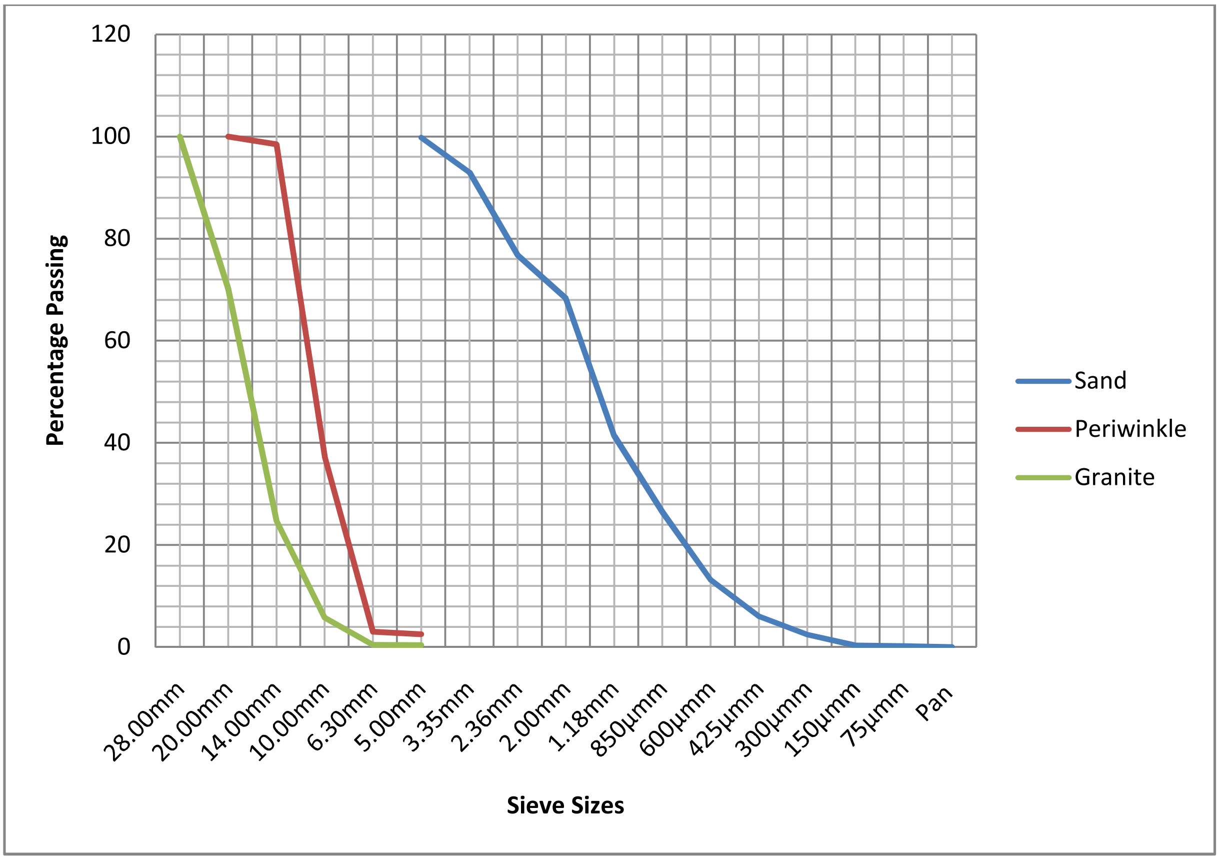


Figure 1: Sieve Analysis of Materials Used

3.3 Specific Gravity

The specific gravities of sharp sand, granite and periwinkle shell obtained in this research work are 2.58, 2.79 and 1.28 respectively. Dahiru et al, 2018 stated the specific gravity of gravel to be 3.20, sand to be 2.66 and that of periwinkle shell as 1.73.

Bharathi et al, 2016 got the specific gravity of fine aggregate as 2.59, while for coarse aggregate is 2.6. Ayegba, 2013 found the specific gravity to be 2.07 for periwinkle shell.Amaziah et al, 2013 found the specific gravity for crushed periwinkle shells, river sand and gravel as 2.10, 2.64 and 2.57 respectively.

Ibearugbulem and Ajoku, 2016 found the specific gravities of sharp sand, river gravel, and periwinkle shells as 2.602, 2.718 and 1.16 respectively.

Anosike, 2011 found the specific gravities of sand and granite to be 2.65 and 2.8 respectively.

Olali, 2019 stated in his research work the specific gravity of periwinkle shells as 1.154and classified aggregates having specific gravities ranging from 2.5 - 2.7 as normal weight.

From the data and analysis of periwinkle shells by previous researchers and this work, the periwinkle shell can be classified as lightweight aggregate because it falls below the stated classification.

Table 5: Summary of the physical properties of the aggregates

Properties	Sand	Granite	Periwinkle shell
Specific gravity	2.58	2.79	1.28
Bulk density	1695.65	1820.74	706.86
Moisture content	2.49	0.2	4.13
Water absorption	20.02	1.83	5.13

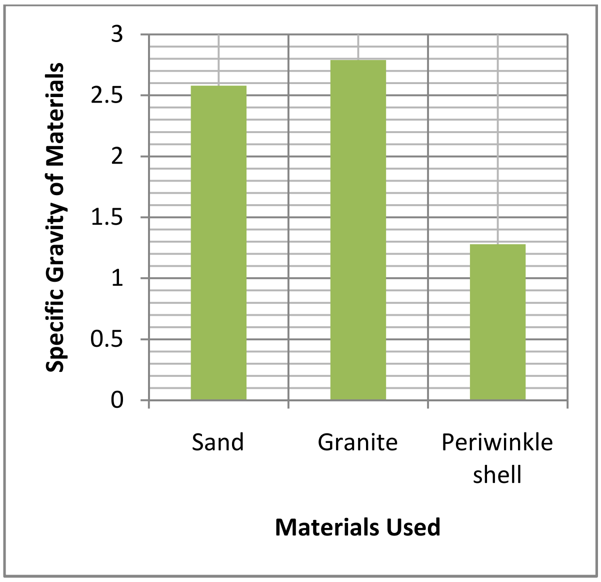


Figure 2: Specific Gravity of Materials Used

3.4 Bulk Density

The bulk densities of the materials used for the work are shown in Table 5 and Figure 3.Adewuyi and Adegoke, 2008 found the average bulk density of the periwinkle shells and crushed granite to be 1243 and 2860kg/m^3 respectively.Ayegba, 2013 got the bulk density of periwinkle shells for loose and compacted bulk densities to be 515kg/m^3 and 590kg/m^3 respectively.

Amaziah et al, 2013 stated the values of the bulk density for crushed periwinkle shells, river sand and gravel as 1504kg/m^3, 1636kg/m^3 and 1291kg/m^3 respectively.

Ibearugbulem and Ajoku, 2016 investigated and recorded the un-compacted bulk densities of sharp sand, river gravel, and periwinkle shells as 1670kg/m^3, 1588kg/m^3 and 520kg/m^3 respectively.Dahiru et al, 2018 stated the bulk densities of sharp sand, gravel, and periwinkle shells as 1681.4kg/m^3, 1660.8kg/m^3 and 619.90kg/m^3 respectively.

Olali , 2019 also stated the compacted bulk density of periwinkle shells as 552.10kg/m^3.The values got for this work falls within the range of the values from other researchers.

Figure 3: Bulk Density of Materials Used

3.5 Moisture Content

The average value of natural moisture content for sand, granite and periwinkle shells used for this research work are 2.49, 0.2, and 4.13% respectively as shown in Table 5 and Figure 4.

Adewuy and Adegoke, 2008 got 1.44% as the moisture content of periwinkle shells.

Amaziah et al, 2013 stated the values of the moisture content for crushed periwinkle shells, river sand and gravel as 7.8, 2.76 and 11.65% respectively.

The values gotten fall within the range of values of the earlier researchers.

Figure 4: Moisture Content of Materials Used

3.6 Water Absorption

Water absorption test was carried out and average percentage value of 20.02, 1.83, and 5.13 were calculated and recorded for sand, granite and periwinkle shells respectively as shown in Table 5 and Figure 5.

Ibearugbulem and Ajoku, 2016 stated the water absorption of river gravel and periwinkle shells as 0.8 and 2.4% respectively.

Dahiru et al, 2018 got the values of water absorption to be 10, 9, and 25% for sharp sand, gravel, and periwinkle shells respectively.

Olali , 2019 found the value of the water absorption test of periwinkle shells used for the research work to be 3.05%.

Neville & Brooks, 2010 stated important requirement for a dry normal aggregate that aggregate must have minimum compacted bulk density of 1200 kg/m^3 and the bulk density of periwinkle shells required for the production of concrete for this work falls below the required bulk density of normal aggreagate.

Figure 5: Water Absorption of Materials Used

3.7 Aggregate Impact Value (AIV)

The aggregate impact and crushing values for granite and periwinkle shells are shown in Table 6, Figures 6, and Figure 7.

Ibearugbulem and Ajoku, 2016 did record the aggregate impact values (AIV) of river gravel and periwinkle shells as 21.49 and 33.50% respectively.

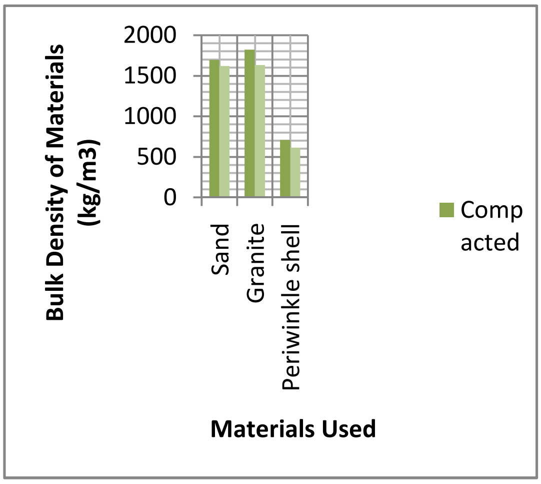
Olali , 2019 found the aggregate impact value of periwinkle shells used to be 14.23%.

Shetty, 2009 stated that the wearing surface aggregates were expected to have maximum impact values of 30% and concrete aggregates are to have maximum values of 45%.

The results the periwinkle shell shows low resistance to impact when compared to granite. According to the results of impact values of periwinkle shell, it clearly shown that the periwinkle shell used is not for wearing course but can be used for some structural element.

Table 6: Summary of the mechanical properties of the aggregates

Properties	Granite	Periwinkle shell
Impact value (AIV)	12.23	36.38
Crushing value (ACV)	13.66	33.28



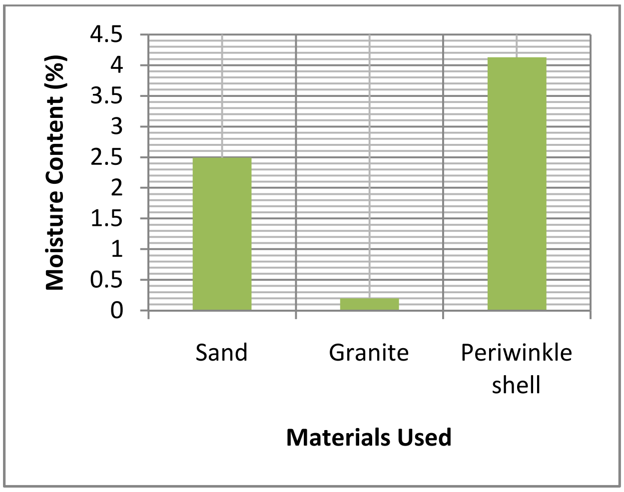


Figure 4: Moisture Content of Materials Used

Figure 3: Bulk Density of Materials Used

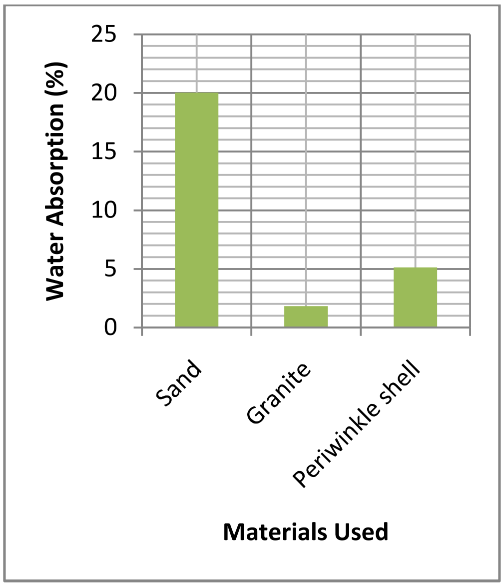


Figure 5: Water Absorption of Materials Used

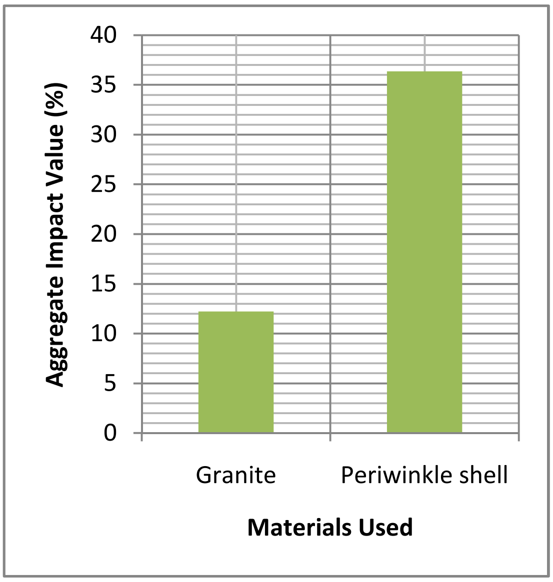


Figure 6: Aggregate Impact Values of Coarse Aggregates

3.8 Compressive Strength

The summary of the result of compressive strength and the corresponding densities of concrete for 7 and 28days is shown in Table 7.

Osarenmwinda and Awaro, 2009 investigated and found the 28 days compressive strength of concrete made with periwinkle shells at varying percentages and mix designs to range from 14.00 N/mm^2 to 25.67 N/mm^2.

Agbede and Manasseh, 2009 found and recorded the 28-day density and compressive strength of concrete made with the inclusion of periwinkle shells to be 1944 kg/m^3 and 13.05 N/mm^2 respectively.

Adewuyi and Adegoke, 2008 had minimum 28 day compressive strength of 21 and 15N/mm^2 with the inclusion of periwinkle shells at 35.4 and 42.5% for 1:3:6 and 1:2:4 mixes respectively.

Bamidele, 2002 noted and stated in the research work that the 28 days compressive strength of the concrete made with 100% periwinkle shells ranged from 11.77N/mm^2 to 15.65N/mm^2.

Ettu et al, 2013 had the compressive strength which support the reinvestigation of concrete produced using granite and periwinkle shells.

3.9 Flexural Strength

The 7 and 28 days summary result of the flexural strength and respective densities are also given in Table 7.Ibearugbulem and Ajoku, 2016 concluded that the 28 days laboratory flexural strength value to be satisfactory.

Table 7: Summary of the mechanical properties and densities of concrete

COMPRESSIVE STRENGTH		FLEXURAL STRENGTH		DENSITY OF CUBES		DENSITY OF BEAMS	
7days	28days	7days	28days	7days	28days	7days	28days
14.70	15.02	5.65	8.10	1765.29	2189.35	1946.67	2106.67
14.07	19.30	6.48	9.13	1814.60	2159.76	2100.00	2133.33
12.71	13.72	5.30	8.18	1587.77	2179.49	1880.00	2146.67
12.44	13.56	5.85	8.38	1558.19	2130.18	1880.00	2086.67
12.81	13.60	6.18	8.63	1587.77	2179.49	1880.00	2133.33
12.30	14.15	5.83	8.48	1558.19	2159.76	1900.00	2020.00
10.30	11.14	5.70	8.08	1627.22	2179.49	1953.33	2106.67
14.33	14.74	5.98	8.75	1686.39	2199.21	1986.67	2120.00
10.70	10.92	5.60	7.40	1508.88	2179.49	1966.67	2126.67
10.13	10.37	4.75	6.58	1538.46	2189.35	1993.33	2140.00
12.09	12.36	4.33	6.48	1508.88	2199.21	1946.67	2113.33
9.33	14.10	5.68	8.25	1558.19	2179.49	1986.67	2120.00
15.33	15.69	7.55	10.88	1804.73	2189.35	1940.00	2106.67
6.95	10.50	4.80	7.05	1548.32	2100.59	1993.33	2113.33
13.41	14.46	7.28	10.35	1646.94	2120.32	1960.00	2146.67

17.45	17.84	6.20	9.50	1765.29	2199.21	1973.33	2140.00
9.78	9.99	4.65	6.25	1548.32	2080.87	1966.67	2073.33
13.26	13.56	4.88	7.30	1646.94	2061.14	1960.00	2120.00
13.97	14.30	7.20	9.38	1775.15	2169.63	2040.00	2106.67
10.41	14.31	5.75	8.08	1577.91	2051.28	2066.67	2100.00
11.26	11.63	5.73	8.63	1568.05	2149.90	1873.33	2080.00
11.85	12.52	5.23	8.13	1587.77	2199.21	1826.67	2060.00
17.14	18.49	7.78	11.13	1656.80	2189.35	1966.67	2140.00
11.56	13.75	6.83	9.18	1587.77	2159.76	1880.00	2093.33
10.46	14.33	5.30	7.00	1597.63	2189.35	1960.00	2140.00
12.13	13.10	5.33	7.50	1587.77	2140.04	2026.67	2100.00
9.88	14.92	7.93	11.25	1568.05	2169.63	2013.33	2126.67
14.93	20.49	7.38	10.50	1715.98	2199.21	2046.67	2106.67
17.88	21.04	9.03	12.13	1794.87	2140.04	2026.67	2113.33
9.85	13.53	4.33	6.13	1617.36	2199.21	2013.33	2126.67
6.59	9.96	3.53	5.08	1459.57	2041.42	2080.00	2126.67
CONTROL MIX							
17.01	17.48	7.23	10.38	1923.08	2169.63	2006.67	2113.33
11.56	13.60	4.78	6.75	1528.60	2189.35	2086.67	2120.00
14.49	17.04	6.48	9.25	1587.77	2169.63	1933.33	2133.33

4 CONCLUSION

From the findings of this work, the results of the 28 day densities of all the samples of concrete made of periwinkle shells at 20, 25 and 30% replacement for this research work fall below the normal density of concrete of 2400kg/m^3. The maximum compressive and flexural strengths of concrete at 28 days are 19.30 N/mm^2 and 11.13 N/mm^2. The values show that the concrete can be used as structural lightweight concrete since the compressive strength is more than 17 N/mm^2.

REFERENCES

Olutoge F. A., Okeyinka O. M., and Olaniyan O. S.,(2012) "Assessment of the suitability of periwinkle shell ash as partial replacement for ordinary portland cement in concrete," Intemational Journal of Research and Reviews in Applied Sciences, Vol. 10 No.3, pp. 428-434.

Ede A.N., Adebayo S.O., Ugwu E.I. and Emenike C.P., (2014)"Life Cycle Assessment of Environmental Impacts of Using Concrete or Timber to Construct a Duplex Residential Building", IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE), Volume 11, Issue 2 Ver. I, pp.62-72.

Oyedepo O. J. (2016), Evaluation of the Properties of Light weight Concrete Using Periwinkle Shells as a Partial Replacement for Coarse Aggregate, Department of Civil and Environmental Engineering, Federal University of Technology Akure, Nigeria. J. Appl. Sci. Environ. Manage, Vol. 20 (3) 498-505.

Adewuyi A. P., Franklin S. O., Ibrahim K. A. (2015). Utilization of Mollusc Shells for Concrete Production for Sustainable Environment, International Journal of Scientific & Engineering Research, Volume 6, Issue 9, ISSN: 2229-5518

Amaziah W. O., Idongesit U. F., & Theodore A. I. (2013). Exploratory Study of Crushed Periwinkle Shell as Partial Replacement for Fine Aggregate in Concrete. Journal of Emerging Trends in Engineering and Applied Sciences, 4(6), 823-827.

Ayegba C. (2013). Strength Characteristics of Concrete Made with Rice Husk Ash as Partial Replacement of Cement Using Periwinkle Shell as Coarse Aggregate, International Journal of Engineering Research & Technology (IJERT), Vol. 2 Issue 8, ISSN: 2278-0181.

Bharathi R.Y., Subhashini S., Manvitha T., Lessly S.H., (2016). Experimental Study on Partial Replacement of Coarse Aggregate by Seashell & Partial Replacement of Cement by Flyash, International Journal of Latest Research in Engineering and Technology (IJLRET), 2, 69-76.

Bilal E., (2006). Effect of reducing coarse aggregates on concrete strength, Construction and Building Materials 20, 149-157.

British Standard,BS 8110 :Part 2 :1985

Dahiru, D., Yusuf, U. S. and Paul, N. J. (2018) “Characteristics of Concrete Produced

WithPeriwinkle and PalmKernel Shells as Aggregates", FUTY Journal of the Environment, Yola, Nigeria.

Ettu L. O., Ibearugbulem O. M., Ezeh J. C., & 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, 2(3), 54-59.

Ibearugbulem O. M., Ajoku C. A. (2016). Prediction of the Flexural Strengths of Lightweight Periwinkle Shell-River Gravel Concrete, International Journal of Engineering Sciences & Research Technology, 5(2): 2277-9655.

Olali I. I. (2019). Modelling of the Compressive Strength of Blocks Made with Periwinkle Shells as Coarse Aggregate, (M.Eng.Thesis), Department of Civil Engineering, Federal University of Technology, Owerri.

Osarenwinda, J. O. &Awaro, A. O. (2009). The Potential Use of Periwinkle Shell As Coarse Aggregate For Concrete. Advanced Material Research, 62, 39-43.