



# Periwinkle Shells as Partial Replacement for Gravel in Light Weight Concrete

<Oguntayo, A. A.><sup>1</sup>, <Ogunwemimo, I. O.><sup>2</sup>, <Akanni, A. O.><sup>3</sup>

<sup>1, 2, 3</sup> Department of Civil Engineering  
Osun State Polytechnic, Iree, Nigeria

**Abstract:** This paper reports the use of periwinkle shells as partial replacement of gravel aggregate in the production of light weight concrete. Physical and mechanical properties of periwinkle shells were determined. A total of 32 concrete cubes of size 150 x 150 x 150 mm with 5%, 10%, and 15% weight of periwinkle shells in replacement of gravel were cast, crushed and their compressive strengths were determined. After cured for 28days, concrete without periwinkle shells had compressive strength of 23.25N/mm<sup>2</sup> while 5%, 10%, and 15% replacements of gravel with periwinkle shells had 14.05N/mm<sup>2</sup> 11.5N/mm<sup>2</sup> and 9.3N/mm<sup>2</sup> respectively. The results also showed that the compressive strengths of concrete without replacement of gravel with periwinkle shells cured for 28days had 19%, 24% and 27% greater than 5%, 10%, and 15% replacements of gravel with periwinkle shells respectively. The concrete cube with 10% replacement of gravel with periwinkle shells cured for 28days had density 2489.1kg/m<sup>3</sup>

**Keywords:** Periwinkle shells, gravel, concrete, paste.

## 1. Introduction

In Nigeria, like any other developing countries, the problem of shelter assuming increasing dimensions with the consistent increase in the cost of building materials and this has limited the proportion of Nigerians who can afford to build their own houses (Adewuyi and Adegoke, 2008). The growing concern of resource depletion and global pollution had challenged many researchers and engineers to seek and develop new materials. These include the use of by-products and waste materials in building construction. Many of these by-products are used as aggregate for the production of lightweight concrete.

Concrete is a combination of cement, fine aggregate, coarse aggregate, and water which are mixed in a particular proportion to get a particular strength. The cement and water react together chemically to form paste, which binds the aggregate particles together. Approximately three-quarters of the volume of concrete is occupied by aggregates, (Neville, and Brooks, 2002). The strength of concrete is adversely and significantly affected by the presence of voids in the compacted mass, it is vital to achieve a maximum possible density, Dahunsi (2002), tested the compressive strength of concrete made from periwinkle shell in combination with granite and reported that it has lower strength when compared with concrete made with granite alone.

(Gupta, and Gupta, 2004), stated that aggregate is not an inert material filler and its physical, thermal, and chemical properties influence the performance of concrete to a great extent. Gravel aggregates acquired as the result of shifting quarried rock and by crushing natural stone rock. In strength, gravel aggregates are inferior to granite aggregates but they also have their advantages; their radioactive background is usually very low and they are cheaper than granite aggregate,

(Shetty, 2006). They are two types of gravel aggregate, namely scabbled and gravel aggregates.

Periwinkles are small greenish blue marine snails with spiral conical shell and round aperture. The average winkle life span is three years and it grows to a shell height of 20mm, but the largest recorded winkles grew up to 52mm. They are common in the riverine areas and coastal regions on Nigeria where they are used as food. The hard shells which are regarded as wastes ordinarily posed environmental nuisance in terms of its unpleasant odour and unsightly appearance in open dump sites located at strategic places are now being used as coarse aggregates in full or partial replacement for expensive, unaffordable or unavailable crushed stones or local gravels.

Lightweight concrete has become popular in recent years because of its thermal insulation and fire-resistant properties, its facility for being easily drilled, nailed and chased, its ease of handling, and reduced formwork requirements (Shetty, 2006). Lightweight concrete has density that varies from 300kg/m<sup>3</sup> to 1850kg/m<sup>3</sup> (Neville and Brooks, 2002). There are many advantages of having low density. It helps in reduction of dead load, increases the progress of building, and lowers haulage and handling cost. It has a relatively low thermal conductivity, a property which improves with decreasing density, (Gulpa *et al.*, 2004). Basically there is only one method for making concrete light that is by the inclusion of air in concrete. This is achieved in actual practice by three different ways.

- i. By replacing the usual mineral aggregate by cellular porous or light-weight aggregate.
- ii. By introducing gas or air bubbles in mortar. This is known as aerated concrete.
- iii. By omitting sand fraction from the aggregate. This is called 'no-fines' concrete.

One of the disadvantages of conventional concrete is the high self weight of concrete. Density of the normal concrete is in order of 2200 to 2600kg/m<sup>3</sup> (Shetty, 2006). This heavy self weight will make it to some extent an uneconomical structural material. The objective of this study is to find useful replacement of gravel in concrete.

## 2. Materials and Method

### 2.1 Selection of Materials

The choice of ordinary Portland cement for this report conforms to the requirement of BS 12. Fine sand used was free of organic materials, silt, and clay. Gravel aggregate was obtained from quarry in Boripe Local Government of State of Osun. Periwinkle shells were obtained in sufficient quantity from Aleshinloye market in Ibadan where they were dumped after removal of the edible portion. Mould of 150mm X 150mm X 150mm was used for casting of concrete cubes.

### 2.2 Methods

Sieve analysis: a process of dividing a sample of aggregate into fraction of same particle size. Its purpose is to determine the grading or size distribution of the aggregate. This was done in accordance with BS 882:1992. Batching operation by weight approach was adopted in this study. Mixes of 1:2:4 (cement: fine aggregate: coarse aggregate) were investigated with water/cement ratio 0:6. The mould was assembled prior to mixing and properly lubricated for easy removal of hardened concrete cube. Concrete mixes were prepared in percentage by weight of gravel to periwinkle shells as coarse aggregate in order of 0%, 5%, 10% and 15%. The mixture was properly turned with shovel and then fed into lubricated mould. Workability of concrete batches for different percentage of periwinkle shells was determined using slump test. Water curing method was adopted for the curing of cubes. The specimens were made in accordance with BS 1881; the moulded concrete was given 24hours to set before demoulding. They were then immersed in a large curing tank in order to obtain good quality concrete. Cubes prepared were cured for 7days, 14 days 21days and 28days. The aggregate crushing value (ACV) test was carried out as prescribed by BS 812. The compressive strengths of the cubes were tested in accordance with BS 1881.

## 3. Results and Discussion

The Tables 1-6 shows the result of the compressive strength of concrete cubes prepared at various percentages replacement of cement with metakaolin The Table 1 shows the particle size distribution of gravel. The Table 2 shows particle size distribution of periwinkle shells. The Table 3 shows the particle distribution of sand.

Tables 1, 2 and 3 show the grading of gravel, periwinkle shells and sand respectively. It can be deduced from the tables that these aggregates are well graded and concrete produced from such aggregates would be free from segregation if properly mixed. The Table 4 shows the mix ratio for different weights of gravel replaced with periwinkle shells and other materials in the mix.

**Table 1:** Grading of gravel

S/N	B.S Sieve size (mm)	Weight Retained (g)	Weight Passed (g)	Percentage Retained	Percentage Passed (g)
1	20.00	1000	1500	40.00	60.00
2	10.00	1284	216	51.36	8.64
3	6.300	138	78	5.52	3.12
4	5.00	27	51	1.08	2.04
5	4.75	18	33	0.72	1.32
6	2.36	24	9	0.96	0.36
	Pan	5	4	0.2	0.16
	Total	2496	1891	99.84	75.64

**Table 2:** Grading of Periwinkle Shells

S/N	B.S Sieve size (mm)	Weight Retained (g)	Weight Passed (g)	Percentage Retained (g)	Percentage Passed (g)
1	20.00	3.20	2496.80	0.13	99.87
2	10.00	225.00	2271.80	9.00	90.87
3	6.300	1985.80	286.00	79.43	11.44
4	5.00	95.00	191.00	3.80	7.64
5	4.75	75.00	116.00	3.00	4.64
6	2.36	79.00	37.00	3.16	1.48
	Pan	32.00	5.00	1.28	0.20
	Total	2495	5403.6	99.80	216.14

**Table 3:** Grading of Sand

S/N	B.S Sieve Size	Weight Retained (g)	Weight Passed (g)	Percentage Retained	Percentage Passed
1	9.50mm	49.50	2450.50	1.98	98.02
2	5.00mm	36.00	2414.50	1.44	96.58
3	4.75mm	55.00	2359.50	2.20	94.38
4	1.70mm	470.50	1889.00	18.82	75.56
5	850µm	683.00	1206.00	27.32	48.24
6	600µm	388.00	818.00	15.52	32.72
7	425µm	255.00	563.00	10.20	22.52
8	212µm	287.00	276.00	11.48	11.04
9	150µm	54.00	222.00	2.16	8.88
1	75µm	113.50	108.50	4.54	4.34
0	63µm	100.00	8.50	4.00	0.34
1	Pan	2.5	6.00	0.100	0.24
1	Total	2494	12321.5	99.76	492

**Table 4:** Mix ratio for different weights of gravel replaced with periwinkle shells.

Materials	Weight (kg) Without replacement of gravel with periwinkle shells	Weight (kg) 5% replacement of gravel with periwinkle shells	Weight (kg) 10% replacement of gravel with periwinkle shells	Weight (kg) 15% replacement of gravel with periwinkle shells
Cement	10	10	10	10
Sand	20	20	20	20
Gravel	40	38	36	34
Periwinkle shells	0	2	4	6

**Table 5:** Workability of concrete batches using slump test

Periwinkle shells: Gravel (%)	0:100	5:95	10:90	15:85
Slump 1:2:4 mix (mm)	18	15	13	11

The Table 5 shows the result of consistence of the concrete mix in a fresh state.

**Table 6:** Compressive strength of concrete cubes with periwinkle shells

Percentage of periwinkle shells	7 days compressive strength (N/mm <sup>2</sup> )	14 days compressive strength (N/mm <sup>2</sup> )	21 days compressive strength (N/mm <sup>2</sup> )	28 days compressive strength (N/mm <sup>2</sup> )
0	19.5	20.5	21.5	23.25
5	11.05	12.6	13.3	14.05
10	9.5	10.5	10.95	11.5
15	7.7	8.2	8.9	9.3

The slump test gives an indication of the uniformity of concrete from batch to batch (Shetty, 2006). It is obvious from the data in the Table 5 that workability of concrete reduces as the percentage of periwinkle shells increases. This can be attributed to the fact that since gravel is denser than periwinkle shells and replacement is by weight, the specific surface area increases as periwinkle contents increase (Adewuyi and Adegoke, 2008). Also the reduction in workability with the percentage increase in periwinkle shells could be attributed to the shape and texture of the periwinkle shells as angular, elongated and rough-textured aggregate will require more water to produce workable concrete than smooth and rounded aggregate (Shetty, 2006)

The compressive strength of concrete cube specimens for different percentages of periwinkle shells are shown in Table 6 for concrete mix 1:2:4, for this mix, compressive strength decreases as periwinkle shells content increases (as percentage of gravel decreases). The compressive is maximum for specimens with 100% gravel and minimum when periwinkle shells content is 15%. The main explanation for this is that as the quantity of periwinkle shells increases the proportion of cement paste becomes insufficient to make effective bond with the coarse aggregate because of high volume occupied by periwinkle shells. Also as the age of the concrete increases the strength also increases as it can be seen by the loading test (Adewuyi, and Adegoke, 2008). The strength of concrete increases with age for both types of concrete as it can be seen from loading test.

The aggregate crushing values (ACV) of 59.8% and 27.7% were obtained for periwinkle shells and gravel respectively. Aggregate crushing value obtained for periwinkle shells suggests that periwinkle shells are not suitable for normal dense concrete because a maximum ACV value of 30% was recommended for normal dense concrete (BS 812). It can be combined with gravel in appropriate proportion to produce the desired concrete. Densities of cubes obtained from the concrete mix are shown in the Table 7.

**Table 7:** Density of cubes for different percentages of periwinkle shells as coarse aggregate for concrete

Percentage of periwinkle shells	7 days density (kg/m <sup>3</sup> )	14 days density (kg/m <sup>3</sup> )	21 days density (kg/m <sup>3</sup> )	28 days density (kg/m <sup>3</sup> )
0	2847.5	2852.85	2849.8	852.85
5	2697.5	2697.75	2705.2	2749.49
10	2456.35	2456.5	2478.75	2489.1
15	2395.44	2398.54	402.78	2407.43

The density of concrete can be used to classify the mix considering the 28 days density of periwinkle-gravel concrete cubes. The density reduces as percentage inclusion of periwinkle shells increases. The minimum densities

corresponding to 10% periwinkle shells are 2455.35-2489kg/m<sup>3</sup> for concrete mix 1:2:4. These fall within the range of normal weight concrete 2200-26000 kg/m<sup>3</sup> (Shetty, 2006). It is apparent that partial replacement of gravel with periwinkle shells up to 10% for mix 1:2:4 can still be regarded as normal weight concrete.

#### 4. Conclusion

The following conclusions can be drawn from this study:

- The strength of concrete made from partial replacement of gravel with periwinkle shells is determined based on the properties of shells and the various percentage replacements.
- Periwinkle shells can be used as a light weight aggregate as partial replacement of coarse aggregates in construction works.
- The rate at which strength develops in the mix containing periwinkle shells is similar to those in conventional gravel concrete.

#### References

- Brooks, J. J., & Megat-Jonari, M. A. (2001). Effect of Metakaolin on Creep and Shrinkage of Concrete. In: Cement and Concrete Composites, 23, 495-502
- Dinakar, P. (2011) High Reactive Metakaolin for High Strength and High Performance Concrete. *The Indian Concrete Journal*, pp-28-34
- Femandez, R., Martena, F., and Scrivener, K. L. (2011). The Origin of the Pozzolanic Activity of Clay Minerals: comparison between kaolinite, illite, and montmorillonite. *Cement and Concrete Research* 41, 113-122
- Kakali, G., Perraki, T., Tsivilis, S., Badogiannis, E. (2001). Thermal Treatment of Kaolin: The effect of mineralogy on the pozzolanic activity. *Applied Clay Science*, 20, 73-80
- Patil, B. B. and Kumbhar, P. D. (2012). Strength and Durability Properties of High Performance Concrete, concrete in corpora ting high reactivity metakaolin, *International Journal of Modern Research*, 2(3), 1099-1104
- Shetty, M. S. (2006). *Concrete Technology*. Ram Nagar, New Delhi: S.Chand and Company Ltd, p.7361.
- Snelling, R., Mertens, G., and Elsen, J. (2012). Supplementary cementitious materials, *Reviews in Mineralogy and Geochemistry* 74, 211-278
- Supriya, K. N., Hemalata, K. M, and Balkrisling, D. (2001). Properties of Concrete with Metakolin and Fly Ash as Partial Replacement of Cement. *International Journal of Earth Sciences and Engineering*. 04(06), 1059.