IMPACT: International Journal of Research in Engineering & Technology
ISSN(P): 2347-4599; ISSN(E): 2321-8843
Vol. 7, Issue 5, May 2019, 1-10

MODELING OF THE COMPRESSIVE STRENGTH OF BLOCKS MADE WITH PERIWINKLE SHELLS AS COURSE AGGREGATE

C. E. Okere, J. I. Arimanwa, O. M. Ibearugbulem & I. I. Olali

Research Scholar, Department of Civil Engineering, Federal University of Technology, Futo Owerri, Nigeria

Received: 21 Mar 2019 **Accepted:** 04 May 2019 **Published:** 14 May 2019

ABSTRACT

This research work presents Modeling of the compressive strength of blocks made with periwinkle shells as coarse aggregate. Ibearugbulem regression method was used for the development of the models. Eight mix ratios were used in modeling of the block samples. These were 1:6.5:0, 1:6:0.5, 1:5.5:1.0, 1:5.0:1.5, 1:4.5:2.0, 1:4.0:2.5, 1:3.5:3.0 and 1:3.0:3.5. The size of the blocks molded was 125x225x450mm. The materials used for the production of the block samples were cement, river sand, periwinkle shells and portable water. Two curing methods were used; these were a sprinkling of water at 6^{th}, 12^{th}, and 24^{th} hourfor 7, 14, 21 and 28 days curing ages, and total immersion in water for the same curing ages after 24 hours of molding of the block samples. A total of 96 blocks were molded for each curing age with 12 blocks for each mixing ratio. These gave a total of 384 blocks for the four curing ages. The blocks were subjected to a compression test after curing. For the first method of curing i.e sprinkling of water, there is a progressive increase in the compressive strength of the blocks as the quantity of periwinkle shells increases. The minimum compressive strength at the 24^{th} hour of sprinkling at 7 days curing age with a numeric value of 3.1190N/mm^2, while the maximum compressive strength occurred at the 6^{th} hour of sprinkling for 28 days curing age with the numerical value of 28.84 N/mm^2. For the second method of curing, minimum compressive strength occurs at 7^{th} day of immersion with numeric value of 4.36 N/mm^2 and the maximum compressive strength occur at 28 days of immersion of the block sample with numeric value of 32.72 N/mm^{2}The models were tested for adequacy using the 95% confident limit using the Fisher's test and found to be adequate. The minimum percentage difference was recorded at 28days curing and 24^{th} hourly curing by a sprinkling of water with a numerical value of 0.01 while the corresponding maximum value was attained at 7 days curing age at the 12^{th} hourly curing by the sprinkling of water with the numeric value of 22.97. These show that there is no significant difference between the laboratory and model compressive test result. In conclusion, the comparative cost analysis of the periwinkle blocks and normal blocks were calculated, it was found that the periwinkle block gave a 25% saving over the normal block.

KEYWORDS: *Blocks, Periwinkle Shells, Mix Ratio, Curing, Compressive Strength, Models*

INTRODUCTION

Blocks are molded element used in the construction of structures such as houses. There are basically two types of blocks depending on the material composition. Those made with cement and sand (fine aggregate) is called sandcrete blocks while those made with the addition of a third ingredient such as coarse aggregate are called concrete blocks (Allen, 2001). Generally, blocks are used in the construction of both residential and commercial building, agricultural storage facilities, fence, and drainages. The significance of blocks in virtually all civil engineering practice and building construction works cannot be overemphasized. Over the years, many researchers and engineers have source and develop new materials relying on renewable resources as alternative suitable inexpensive locally available materials that could be substituted for fine aggregate or coarse aggregate in the production of blocks (Adewuyi et al, 2015).. These materials include the use of by-products and waste materials in building blocks construction. (Agbede and Manasseh, 2009).

It is even more compelling with the falling crude oil price and global economic recession coupled with the market inflationary price, to source for locally available material that replaces the conventional ones with the intent of reducing the high cost of construction (Maroliya, 2012). Numerous achievements have been made in these regards and the subject is attracting attention due to its functional benefit of waste reusability and sustainable development. Reduction in construction costs and the ability to produce light-weight structures are added advantages. Attention is now drawn to the use of periwinkle shells as coarse aggregate which is a locally available material in the production of blocks.

Periwinkles (Botanical name is Nodilittorina radiata) are small greenish blue marine snails with spiral conical shell and round aperture. The average periwinkle lives three years and grows to a shell height of 20mm, but the largest recorded periwinkle grew to 52 mm (Adewuyi and Adegoke, 2008). They are common in the riverine areas and coastal regions of Nigeria where they are used for food. The hard shells are regarded as waste which ordinarily posed environmental nuisance in terms of its unpleasant odour and unsightly appearance in open-dump sites located at strategic places and is now being considered as coarse aggregates in full or partial replacement for expensive, unaffordable or unavailable crushed stones or locally washed gravels (Agbede and Manasseh, 2009).

This paper, studies the use of periwinkle shells with sand for the production of concrete blocks. The compressive strengths of such blocks were evaluated for various mix ratios. The economic implications were also investigated. A load bearing block could be sandcrete or concrete blocks. They bear or supports the load above it and conduct the same including its own weight unto the foundation (Allen, 2001). It acts as a structural element like beams, columns or floors slab. This is as shown in Figure 1.1a. A load-bearing wall is a wall made from load bearing blocks. Some of the more common load-bearing masonry used today is brick, stone and concrete blocks. (Allen, 2001)

The Nigeria Industrial Standard (NIS 87:2000) prescribes the minimum requirements and uses of Sandcrete blocks and other products including; quality of materials; methods of production and testing of the final product in order to ensure compliance to the prescribed standard. The NIS 87: 2007 standard specified minimum compressive strength value of 2.5 N/mm^2 for non-load bearing or 3.5 N/mm^2 for load-bearing walls. However, the British Standard Code of Practice for use of masonry (BS 5628:1985: Part 2) gave a compressive strength of 7 N/mm^2 for concrete blocks. Several models exist in predicting the compressive strength of blocks. Elasticity, plasticity, continuum damage mechanics, plastic fracturing, endochronic theory, Microplane models, etc.

Common, is the Scheffe's simplex and Osadebe's alternative regression models. However, Ibearugbulem's Regression Model was used in this research. The Scheffe's simplex and Osadebe's alternative regression models are suitable for concrete mix optimization but greatly limited in that a predetermined number of experiments must be carried out in order to formulate them and they can only be applied for mix ratios that fall within the predetermined observation points or space, (Ibearugbulem et al., 2013). Ibearugbulem's Regression Model has been formulated to predict concrete strength with unpredetermined experiment or unrestricted mix ratio and space, (Ibearugbulem et al., 2013)

Building masonry walls are extensively used in many countries of the world. The many advantages include durability, strength and structural stability, fire resistance, insulation, and sound absorption among others. Given the rising cost of steel importation and the use of sub-standard material in column construction, it becomes increasing compelling to seek alternative solutions to the use of reinforced column. Blocks of high compressive strength made with periwinkle shells provide a virile solution. If adopted, will not only make building construction more affordable but reduce the rising cost of building materials.

More disturbing is the presence of the periwinkle shells as waste material in many urban centers. It is believed that the conversion of agricultural waste materials like periwinkle shells in the production of blocks will not only provide a ready alternative to useful construction material but also reduces the environmental hazard.

The blocks so made would not only provide additional lateral resistance but could serve as load bearing walls in storey building. In practical terms, blocks made with periwinkle shells would serve as a structural element in transmitting the load from beams/slab to the foundation of the building. This would be a huge saving and make housing more affordable to the populace where relative expensive materials are used in building construction.

load bearing building masonry walls may, simultaneously, provide structure, a subdivision of space, thermal and acoustic insulation as well as fire and weather protection. Load bearing wall construction is relatively cheap but durable and produces external wall finishes of very acceptable appearance. Its construction is flexible in terms of building layout and can be constructed reasonably affordable capital. The adoption and use of load bearing blocks would provide timely employment for teaming youth.

MATERIALS AND METHODS

The materials used in this research were locally sourced. The four primary constituents utilized in producing the building blocks are cement, river sand, potable water, and periwinkle shells.

Materials

Cement*:* The cement used was Ibeto brand of Ordinary Portland cement, produced in Nigeria with properties conforming to BS EN 197-1:2000. The grade of the cement was 32.5 corresponding to the 32.5Mpa at 28^{th} day's strength.

River Sand: The sand was obtained from Otamiri River at Owerri and is free from dirt. The river sand was obtained wet as it was freshly dredged, dried and then graded in the size range of $0.15mm \leq x \leq 4.75mm$ before use. The sand was inspected free from debris and all form of external impurities. This complies with BS 882, 1992,

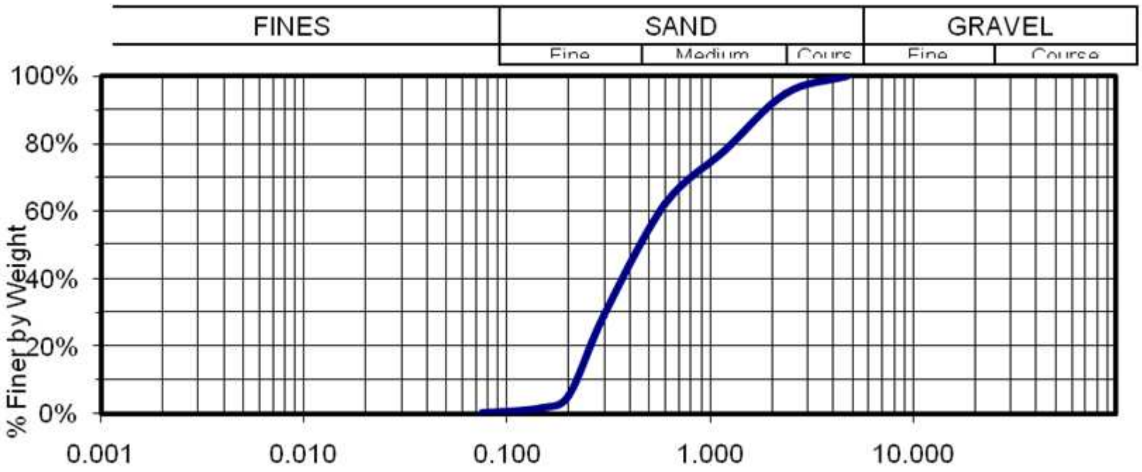

Figure 1: Grain Size Analysis for Sand Grain Diameter (mm)

Water*:* Tap water was used for the mixing and it was properly examined to ensure that it was clean, free from contaminants either dissolved or in suspension and good for drinking as specified in NIS 554: 2007

Periwinkle: The periwinkle shell was sourced from Ekeonunwa market in Owerri municipal local.government area, Imo State. They were wet and mixed up with dirt. Considerable attention was given to pick out deleterious material and then dried in the open air before use. They have a maximum size of 19.5mm.

Methods

A preliminary test of materials before the production of building blocks made with periwinkle shells was carried out. The test methods used in producing the building block conformed to the relevant British Standards tests procedures and that of American Society of Testing and Materials (BS 812: Part 110:1992 and ASTM C131-2003) for strength

This research work is limited to modeling of compressive strength of blocks made with Periwinkle shells as coarse aggregate. The materials used for the laboratory experiment were cement, sand and periwinkle shells. Eight mix ratios were adopted for the experiment. These were

- M1-1:6.5:0 **(ii).** M2 -1:6.0:0.5 **(iii)**. M3- 1:5.5:1.0 **(iv).** M4-1:5.0:1.5
- M5-1:4.5:2.0 (**vi)**. M6-1:4.0:2.5 (**vii).** M7-1:3.5:3.0 (**viii)**. M8-1:3.0:3.5

Two methods of curing were employed for curing the blocks after molding. These were (1) sprinkling method, which was carried at intervals 0, 6, 12 and 24 hours for 7, 14, 21 and 28 days and (2) immersion method, which was done for 7, 14, 21 and 28days respectively.

However, this research work covers the following

- Adopt mix ratios for the production of the block sample
- Curing of the samples of the blocks
- Development of regression models
- Determination of the compressive strength of the blocks in the laboratory

- Prediction of the compressive strength of the blocks from the developed model
- Test for the adequacy of the models

RESULTS AND DISCUSSIONS

From the 7 days compressive strength test results, when considering the mix ratio that has the inclusion of the periwinkle shells (ie from M2 to M8) the lowest minimum compressive strength was 3.390N/mm^2 obtained at mix M2 and 24 hourly curings and the maximum compressive strength was 10.47N/mm^2 at total immersion at M8. Also, there is a progressive rise of compressive strength at initial 6 hourly and 12 hourly curings by sprinkling before descending at 24 hourly curings by sprinkling but there is a rise at total immersion. High compressive strength is obtained at an initial 6 hourly curing but much higher at total immersion for mix ratios with partial replacement of sand with periwinkle shells. Similarly, the mix ratio M1 also shows an initial value, 3.49 N/mm^2 of compressive strength at the 6 hourly curings intervals but higher value, of 4.363 N/mm^2 at curing by total immersion. This represents the condition of no inclusion of periwinkle shells. This goes to confirm that with proper mixing and curing, high strength can be achieved for ordinary sandcrete block under standard laboratory environment.

This trend is replicated for the other curing ages ie 14, 21 and 28 days. However, the compressive strength test results at 28 days gave values almost three times that of seven days compressive strength test. It is observed that the minimum compressive strength is 9.27N/mm^2 obtained at mix M2 and 6 hourly curing by sprinkling and the maximum compressive strength is 32.716N/mm^2 at total immersion at mix M8.

Generally, high compressive strength is obtained at aninitial 6 hourly curing intervals but much higher at curing by total immersions. There is a progressive increase in the compressive strength values as we move vertically downward (from M1 to M8) and a decrease in compressive strength as we move horizontally from left to right as shown in Table 1-4.. It also shows an increase in compressive strength test from M1 – M8 for totally immersion specimens.

The result obtained from the formulated model at 7, 14, 21 and 28 days shows a similar trend with that of the laboratory result. However, the model results have values lower than that of the laboratory. The values obtained by using the regression model and applying the statistical tool show that the values are not significantly different from that obtained from the laboratory experiment.

This was further attested by the result of the percentage difference. It shows that all the results have values of less than 25%. The highest negative value was obtained for mix ratio, M1. This is control mix ratio with no periwinkle shells content.

The model compressive strength result at 7 days curing age is shown in Table 1 Using the development as follows:-

- $\mathbf{M_6} = 16.985Z_1 - 10.215Z_2 + 4.959Z_3 + 80.353Z_1Z_2 - 59.777Z_1Z_3 + 4.018Z_2Z_3 + 469.740Z_1Z_2Z_3$
- $\mathbf{M_{12}} = 14.552Z_1 - 8.934Z_2 + 4.315Z_3 + 66.731Z_1Z_2 - 49.048Z_1Z_3 + 3.390Z_2Z_3 + 401.652_7Z_1Z_2Z_3$
- $\mathbf{M_{24}} = 13.596Z_1 - 8.346Z_2 + 4.031Z_3 + 62.352Z_1Z_2 - 45.830Z_1Z_3 + 3.167Z_2Z_3 + 375.254Z_1Z_2Z_3$
- $\mathbf{M_I} = 18.028Z_1 - 10.719Z_2 + 5.221_3Z_3 + 87.132Z_1Z_2 - 65.291Z_1Z_3 + 4.314Z_2Z_3 + 500.233Z_1Z_2Z_3$

Table 1: Model Compressive Strength Results for Seven Days Curing Age

Model Compressive Strength at 7TH Day - Curing Age –N/mm²				
Mix	**Curing Methods**			
Ratios	**Sprinkling at Different Time Interval**			**Total Immersion**
	6 Hourly	**12 Hourly**	**24 Hourly**	**Immersion**
M1	3.270	3.051	3.120	4.156
M2	3.809	3.416	3.191	5.430
M3	5.263	4.621	4.317	5.509
M4	6.496	5.636	5.266	6.852
M5	7.471	6.431	6.008	7.922
M6	8.155	6.976	6.517	8.683
M7	8.517	7.243	6.767	9.100
M8	8.523	7.019	6.733	9.140

The model compressive strength result at 14 days curing age is shown in Table 2 using the developed model as follows:-

- $\mathbf{M_6}$ = $32.208Z_1$-$18.872\ Z_2 + 9.229Z_3 + 159.758Z_1Z_2$ -$120.580Z_1Z_3 + 7.781Z_2Z_3$ +$808.095Z_1Z_2Z_3$
- $\mathbf{M_{12}}$ = $29.306Z_1$-$17.414Z_2 + 8.484Z_3 + 142.185Z_1Z_2$ -$106.523Z_1Z_3$ +$7.003Z_2Z_3$ +$4815.010Z_1Z_2Z_3$
- $\mathbf{M_{24}}$ =$28.660Z_1$-$17.008Z_2 + 8.289Z_3 + 139.434Z_1Z_2$ -$104.523Z_1Z_3 + 6.853Z_2Z_3$ +$797.618Z_1Z_2Z_3$
- $\mathbf{M_I}$ = $33.641Z_1$-$19.426Z_2$ +$9.538Z_3$ +$170.624Z_1Z_2$ -$129.719Z_1Z_3 + 8.218Z_2Z_3$ +$5940.636Z_1Z_2Z_3$

Table 2: Model Compressive Strength Result for 14 Days Curing Age

Model Compressive Strength at 14th Day - Curing Age -N/mm²						
Mix	**Curing Methods**					
Ratios	**Sprinkling at Different Time Interval**			**Total Immersion**		
	6 Hourly	**24 Hourly**		**24 Hourly**		**Immersion**
M1	9.050	8.522		7.374		8.363
M2	9.275	8.434		8.214		10.828
M3	9.674	9.024		8.741		11.328
M4	12.152	11.229		10.894		12.588
M5	14.142	11.986		12.612		14.738
M6	15.578	14.237		13.838		16.311
M7	16.400	14.924		14.516		17.241
M8	16.545	14.992		14.593		17.464

The model compressive strength result at 21ST day curing age is shown in Table 3 using the developed model as follows:-

- $\mathbf{M_6}$ = $40.469Z_1$-$24.048\ Z_2 + 11.717Z_3 + 196.746Z_1Z_2$ -$147.337Z_1Z_3 + 9.658Z_2Z_3$ +$1127.124Z_1Z_2Z_3$
- $\mathbf{M_{12}}$ = $37.451Z_1$-$22.070Z_2 + 10.777Z_3 + 184.378Z_1Z_2$ -$138.711Z_1Z_3$ +9..000Z_2Z_3 +$1044.231Z_1Z_2Z_3$
- $\mathbf{M_{24}}$ =$35.582Z_1$-$121.566Z_2$ +$10.452Z_3 + 167.458Z_1Z_2$ -$123.983Z_1Z_3 + 8.357Z_2Z_3$ +$987.226Z_1Z_2Z_3$
- $\mathbf{M_I}$ = $42.417Z_1$-$24.903Z_2$ +$12.173Z_3$ +$210.260Z_1Z_2$ -$158.461Z_1Z_3 + 10.217Z_2Z_3$ +$1164.382Z_1Z_2Z_3$]

Table 3: Model Compressive Strength Results for 21st Day Curing Age

Model Compressive Strength at 21st Day - Curing Age -N/mm²				
Mixes	**Curing Methods**			
	Sprinkling at Different Time Interval			**Total Immersion**
Ratios	**6 Hourly**	**12 Hourly**	**24 Hourly**	**Immersion**
M1	9.390	9.231	9.483	10.681
M2	10.799	10.584	10.102	11.958
M3	12.365	11.328	11.132	12.774
M4	15.402	14.183	13.696	16.034
M5	17.825	16.469	15.720	18.651
M6	19.552	18.112	17.133	20.539
M7	20.506	19.039	17.865	21.615
M8	20.610	19.180	17.852	21.800

The model compressive strength for 28 days curing age is given in Table 4 using the developed model as follows:-

- $\mathbf{M_6} = 8.716Z_1+41.962\,Z_2 + 61.997Z_3 + 3.287Z_1Z_2 +4.754Z_1Z_3 + 21.964Z_2Z_3 +1.707Z_1Z_2Z_3$
- $\mathbf{M_{12}} = 46.010Z_1-27.762Z_2 + 13.470Z_3 + 217.533Z_1Z_2 -161.575Z_1Z_3 +10.865Z_2Z_3 +1275.047Z_1Z_2Z_3$
- $\mathbf{M_{24}} =7.261Z_1+35.099Z_2 +51.433Z_3 + 2.751Z_1Z_2 +3.947Z_1Z_3 + 18.304Z_2Z_3 +1.424Z_1Z_2Z_3$
- $\mathbf{M_I} = 56.619Z_1-33.836Z_2 +16.458Z_3 +271.430Z_1Z_2 -202.813Z_1Z_3 +13.492Z_2Z_3 +1569.678Z_1Z_2Z_3$

Table 4: Model Compressive Results for the 28th Day

Model Compressive Strength at 28th Day - Curing Age - N/mm²				
Mix	**Curing Methods**			
Ratios	**Sprinkling at Different Time Interval**			**Total Immersion**
	6 Hourly	**12 Hourly**	**24 Hourly**	**Immersion**
M1	10.737	9.939	8.142	12.961
M2	11.656	10.377	10.148	14.493
M3	16.015	14.313	13.684	17.408
M4	19.703	17.648	16.658	21.583
M5	22.615	20.285	18.982	24.901
M6	24.647	22.133	20.57	27.249
M7	25.701	23.103	21.339	28.517
M8	25.682	23.109	21.211	28.599

CONCLUSIONS

In this research, the need to promote local content and source for locally available materials that provide the needed solution to the basic necessity of shelter has been emphasized. Exploration is made on the use of blocks not just as partition walls but as a load bearing walls that would drastically reduce the cost of the building project when used without reinforced columns.

Also, one of the available abundant materials for the production of blocks is the periwinkle shell. The use of the periwinkle shells has found relevance in the construction industry. It can now be put to use as an essential material in the production of building blocks. The physical characteristic test of the periwinkle shell shows values comparable to normal coarse aggregate and hence recommended for use in the production of a building block.

In this research work, building blocks made of periwinkle shells have been produced with the compressive strength test for 7, 14, 21 and 28 days giving values well above recommended standard by NIS 87: 2007. The laboratory results show that the minimum seven days compressive strength is 3.390N/mm^2 and the maximum compressive strength is 10.47N/mm^2. Similar values were obtained for 14 and 21 days curing ages. The 28 days curing age compressive strength test has a minimum value of 10.205N/mm^2 and maximum value of 32.716N/mm^2. This is anticipated, especially as it concerns its conformity with recognized standards specification for load bearing blocks. The NIS 87:2007 specification gave a minimum compressive strength of 3.5N/mm^2 for load bearing blocks. Considering the compressive strength test values obtained at seven days, the blocks so produced are load bearing blocks made with periwinkle shells, Result also showed that there is no need to cure the blocks for 28days since the seven 7 days compressive strength has comparable values as per NIS 87: 2007 Standard.

Regression model has been formulated for building blocks for curing methods of sprinkling and total immersion. The compressive strength results obtained from the models were subjected to statistical testing using Fishers Test. They were found adequate. The Fishers test values range from 1.025 and 1.118 less than the allowable f-value of 19 from a statistical table at 95% confidence level. The mix ratios from M2 to M8 show high compressive strength that could be used for the production of blocks for the building industry.

REFERENCES

1. *Adewuyi, A. P., & Adegoke, T. (2008). Exploratory Study of Periwinkle Shells As Coarse Aggregates In Concrete Works. ARPN Journal of Engineering and Applied Science, 3(6),1-5.*
2. *Agbede O. I., & Manasseh, J. (2009). Suitability of Periwinkle Shell as Partial Replacement For River Gravel In Concrete. Leonardo Electronic Journal of Practices and Technologies, 15, 59-66.*
3. *Allen, T. (.2001). Fundamentals of Residential Construction, 3rd Edition. Published by John Wiley & Sons, Inc., Hoboken, New Jersey.*
4. *ASTM C143. (1998). Making and Curing Concrete Specimen (Testing Fresh Concrete. Slump Test). ASTM, West Conshohocken, USA.*
5. *BS 882, (1992) "Specification for Aggregates from natural sources,", British Standards Institution London, p3,,*
6. *BS 1881 Part 116, (1983). Methods for Determining Compressive Strengths of Concrete Cubes. British Standard Institution, 2 park Street, London.*
7. *BS 3148,(1980) Tests for water for making concrete, British Standards Institution, British Standard House, 2 Park Street, London, WIY 4AA, BS 5628:2005 – Code of Practice for the Use of Masonry. Part 1, London: British Standard Institution.*
8. *BS 5628:1985: Compressive strength of for concrete blocks. Part 2, London: British Standard Institution.*
9. *BS 5628::(2005) Code of practice for the use of masonry Part 3, London: British Standard Institution.*
10. *BS 8110. (1997). Structural Use of Concrete, Code of Practice for Design and Construction. Part 1, London: British Standard Institution.*

11. *BS 1881. (1990).Testing concrete: Method for determination of compressive strength of concrete cubes. Part 116, London: British Standard Institution*

12. *BS EN 12390. (2000). Making And Curing of Concrete Cubes and Beams Specimens. Part 2, London: British Standard Institution.*

13. *Ibearugbulem, O. M., Mmadu, J. E., & Nwachukwu, A. N. (2014). Determination of Compressive Strength of Sandcrete Block Made with Sand, Periwinkle shell, laterite and cement. International Journal of Engineering and Technical Research, 2(9),19-22.*

14. *Iberugbulem, O. M. (2006). Mathematical Models For Optimisation of Compressive Strength of Periwinkle Shell-Granite Concrete (unpublished Master's thesis).Federal University of Technology, Owerri, Nigeria.*

15. *Rakesh Kumar Sahu & S. P. Mishra,Developing an Imperical Method of Mix Design for High Strength Concrete Using Local Materials, IMPACT : International Journal of Research in Engineering & Technology(IMPACT:IJRET), Volume 3,Issue 3, March 2013, Pp 61-68.*

16. *Ibearugbulem, O. M., Ettu, L.O., Ezeh, J. C., & Anya, U. C. (2013). A New Regression Model For Optimising Concrete Mixes. International Journal of Engineering Science And Research Technology, 2(7), 1735-1742.*

17. *Mbadike, E. M., & Osadebe, N. N. (2013). Application Of Scheffe's Model In Optimisation of Compressive Strength of Lateritic Concrete. Journal of Engineering and Applied Sciences, 9, 17-23.*

18. *Memon, B. A., & Channa, G. S. (2015). Compressive strength of concrete masonry unit made by partial Replacement of fine sand with local sand. Department of Civil Engineering, Quaid-e-Awam University of Engineering, Science &Technology, Nawabshah, Sindh, Pakistan.*

19. *NIS 87: (2004): Nigerian Industrial Standard. Standards for Sandcrete Blocks Approved by Standard Organization of Nigeria (SON), Lagos, Nigeria*

20. *NIS 87: (2007): Nigerian Industrial Standard. Standards for Sandcrete Blocks Approved by Standard Organization of Nigeria (SON). Lagos, Nigeria.*

21. *Osadebe,N. N.(2003).Lecture note on Generalized Mathematical Modelling of Compressive Strength of Normal Concrete as a Multi-variant Function of the Properties of its Constituents.*

22. *Scheffe, H.(1958).Experiment with Mixtures. Journal of Royal Statistics Society B, no 20:344-360.*