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The Compressive Strength and Pozzolanic properties of Millet stem Ash Concrete

O. W. Oseni and M.T. Audu*

Department of Civil Engineering, University of Abuja, Gwagwalada-Abuja, FCT, Nigeria

Corresponding author

KEYWORDS

Compressive Strength, Pozzolanic, Millet Stem Ash, Cement, Concrete, Water - Cement Ratio, % Replacement

A B S T R A C T

Compressive Strength characteristics of concrete are substantial factors in the design of concrete structures. Compressive Strength directly affects the degree to which the concrete with stand load over time. These changes are complemented by deflections in concrete structural elements. The focus of this research is to measure the comprehensive strength of Millet Stem Ash (MSA) mixes with Ordinary Portland Cement (OPC) at 5%, 10%, 15%, 20%, 25%, 30% and 35% to form concrete and to evaluate whether they are acceptable for use in concrete structural elements. A normal concrete mix with OPC at 100% (i.e. MSA at 0%) with concrete grade C25/30 was used as a control at design water/cement ratios of 0.60. A MSA mix at 5%, 10%, 15%, 20%, 25%, 30% and 35% of grade C25/30 and water/ cement ratios of 0.60 and aggregate grading of (0.5-32) mm for fine and coarse was tested for compressive strength, slump and flow test. The results and observations showed that the concrete mixes from MSA at these % ratios can be used as a partial replacement to OPC between (5-25) % mix ratio, the weight/density is lighter than normal concrete and the workability decreases as the percentage MSA increases.

Introduction

Until this time, most publications describe the performance of agricultural products in cement pastes and mortars of rice husk ash, sorghum husk ash etc as pozzolanic materials. The pozzolanic and compressive strength properties of these farm products were investigated by diverse researchers at different time in different places (universities, research institutes and developing centres), however, little or no studies had not been performed on Millet Stem Ash (MSA) pozzolanic properties and its compressive properties. Millet is an agricultural product that is plant annually and very common in tropical countries especially in the northern part of Nigeria. The grains are extracted and the stems are usually dump as waste products. A study to how the dump stems waste could be transformed to pozzolanas will definitely enhance the economy of the farmers and also produce a low cost building material once an economic production method is developed. Therefore, there is need to investigate the properties and the percentage of the millet stem ash could be used as partial replacement in concrete that could produced the desire strength of the concrete mix for structural uses.

The objective of this research is to: Measure the compressive strength of Millet Stem Ash a waste and sustainable material and deduce if it has pozzolanic property and hence could be used as partial replacement to cement for building construction.

Basic concrete mix of grade C25/30 and design water cement ratio of 0.60 was examined for:

0% MSA/Cement, (0.5-32) mm aggregate mix concrete (Control)
5% MSA/Cement, (0.5-32) mm aggregate mix concrete
10% MSA/Cement, (0.5-32) mm aggregate mix concrete
15% MSA/Cement (0.5-32) mm aggregate mix concrete
20% MSA/Cement (0.5-32) mm aggregate mix concrete
25% MSA/Cement (0.5-32) mm aggregate mix concrete
30% MSA/Cement (0.5-32) mm aggregate mix concrete
35% MSA/Cement (0.5-32) mm aggregate mix concrete.

Each of the mixes was subjected to: Compressive Strength, Slump and Flow Test. Samples from the percentage ratio batches were obtained for the concrete grade C25/30 at water-cement ratio of 0.60.

Methodology

The materials and sources, laboratory works carried out to accomplishing the objective of this research is as follows:

Materials and Methods

The materials used in the production of the concrete cubes are sand, gravels, cement, millet stem ash and water.The sand was obtained at Gwagwalada-Abuja-FCT environs and transported to Julius Berger PLC, Quality Control Laboratory, Mpape, Abuja- FCT, for preliminary analysis for its suitability for use in concrete.

The coarse aggregate was obtained within Gwagwalada-Abuja-FCT and transported to Julius Berger PLC, Quality Control Laboratory, Mpape-FCT. The aggregate was washed and allowed to dry naturally, to free it from dirt and impurities according to BS 812, 1975.The cement used was Dangote cement obtained at Gwagwalada-Abuja-FCT. The cement obtained is ordinary Portland cement and as such found applicable in most construction works. It was stored in a place with no direct contact with floor and wall. Grain size analysis of the cement was carried out to know its suitability for the work.

Millet Stem is a waste product in millet farms in rural areas of Gwagwalada-Abuja-Niger-Kaduna State. Millet Stem obtained was packed into sacks to avoid mixing with already decayed once and also from moisture or rain and transported to the Julius Berger PLC, Quality Control Laboratory, Mpape-FCT. The burning of Millet Stem was done at the Laboratory using the oven at 500-600^{o}C.

The source of water used for this work is the borehole water situated in the Julius Berger

PLC, Quality Control Laboratory, Mpape-FCT. The water is potable and clean, which therefore satisfies the required specification for making concrete as described in BS 3148 and is therefore suitable for concrete production.

Experimental Procedures

The study commenced with the collection of Millet Stem from farms around Abuja - Niger-Kaduna-Zaria. The Millet Stem was burnt and its ash collected. The ash was allowed to pass through sieve 0.63 millimetres to the same fineness of cement and was followed by preliminary investigation of the constituent material of the Ordinary Portland cement (OPC) and the Millet Stem Ash (MSA) to determine their suitability for concrete making.

The water content of the materials was determined in the laboratory. The weight of the different cans was noted using an electronic balance M_1 and small amount of samples was put into the can and weighed M_2. The concrete and its contents were heated in an oven for 24 hours. The dry sample and can was finally measured M_3. The moisture content was calculated using the moisture content formula;

$$\% M.C = \frac{M_2 - M_3}{M_3 - M_1} * 100$$

This test was conducted in accordance with BS 137712 by which sieves used for the fine aggregate were 5.0mm, 3.5mm, 2.0mm, 1.18mm, 0.85mm, 0.60mm, 0.425mm, 0.30mm, 0.212mm, 0.150mm, 0.63mm and the bottom pan. Sieves to be used for the concrete coarse aggregate are as follows; 32.00mm, 20.00mm, 16.00mm, 14.00mm, 10.00mm, 6.36mm, 5.00mm and the bottom pan. The sieve mesh was cleaned using iron brush to remove particles that they contain. The electronic balance was used to weigh each of the sieves W_2. The sieves were arranged and 1000g of coarse aggregate W_1 poured in through the sieves and shake properly for the finer material to pass through the sieves. The weight of the sieve and its content were weighed W_3 and from this the weight of samples retained was obtained W_4 using the formula.

Weight of samples retained: $W_4 = W_3 - W_2$

$$\text{Percentage retained} = \frac{W_3 - W_2}{W_1} * 100$$

Where;

W_1 = total weight of sample
W_2 = weight of sieve
W_3 = weight of sieve + sample retained
W_4 = weight of sample retained

Laboratory test was conducted to determine the specific gravity of MHA, sand and gravel in accordance with (CP 100). The apparatus used includes pycnometer, weighing balance, electric shakers, cylinder bottle, dishwasher and spatula. 100g of oven dried was weighed and recorded. Then water was added so that no particle remains inside the dish washer. The cylinder was dried and weighed to the nearest 0.1g (M_1). The cylinder and the sample was weighed on the weighing balance M_2 and the rubber stopper was inserted into the cylinder jar; and immediately the cylinder jar is connected to the electric shaker and it was shaken vigorously for 5 minutes until particles were in suspension. The rubber stopper was then removed carefully and any sample sticking to the stopper of the top of the cylinder jar was washed carefully into the cylinder jar. This was added to the cylinder jar until it reached the 100mm/mark. The sample was allowed to settle for 3 minutes and the cylinder jar was then weighed to the nearest 0.1g (M_3). The glass jar was washed thoroughly and filled completely to the

100mm/mark with water. The cylinder was then dried carefully on the outside and weighed to the nearest 0.1g (M_4). The experiment was repeated on the sample so that two values for specific gravity were obtained in each case, the specific gravity formula,

$$Gs = \frac{M_2 - M_1}{(M_4 - M_1) - (M_3 - M_2)}$$

Generally the aggregate impact value gives a relative measure of the resistance of an aggregate to sudden shock or impact, which in some aggregate differ from its resistance to a slowly applied compressive load with aggregate size longer than 14mm are not appropriate to the aggregate impact test. The standard aggregate impact test is conducted using aggregate passing sieve 14.0mm. If the standard sieve size is not allowable, smaller sieve size may be used but owing to non-homogeneity of the aggregate. The full detail of the method for use is described in BS 812. Impact value was obtained using this formula,

$$\% \text{ AIV} = \frac{\text{Weight of fine retained}}{\text{Weight of aggregate}} * 100$$

Where,

Weight of aggregate = (weight of penetration + weight of pan + aggregate) – (weight of penetration)

This test was conducted in accordance with BS 812 (BS 11975). A graduated cylinder of 500ml capacity was filled to about 50ml using salt solution. The sand sample employed for this work was then poured into the cylinder to a level of 100ml mark. More salt solution was added to reach the 150ml mark. The content was corked and shaken thoroughly for about 15 min. The cylinder was placed on a surface and topped to level the sand. The sample was left standing for up to 3 hrs. The amount of the suspended material was noted. The volume of the sand layer V1 and the silt layer V2 were recorded. Silt content of the sand was calculated using the formula;

$$\text{Content} = \frac{\text{silt layer V2}}{\text{sand layer V1}} \text{ x } 100$$

Material was batched by weight; measurement was done normally using head pan and a balance. The empty weight of the head pan was taken before pouring the sample into the pan; the weight of the pan was added to the weight of the individual material to get required weight of the specimen.

The concrete mix was designed in accordance with the British design mix BS 8110. The method gives proportion in terms of qualities of materials per unit volume of concrete. Care was taken in the selection of the design water-cement ratio of 0.60. Nominal mix of concrete grate C25/30 was used in this research. The mixing was done thoroughly in a rotary concrete mixing machine.

This test was carried out to determine the workability of the concrete. The slum cone was placed on a flat non-porous surface and held down by the foot. The mould was then filled in three layers. Each layer was compacted 25 times with a tampering rod 16mm in diameter and 800 mm long. After the third layer has been well-tempered, the slump cone was removed immediately by raising it up vertically. The height of the slump cone was determined. The measurement was taken from the top of the slump cone to the top of the concrete. The slump was measured as the difference between the heights of the cone to the height of the slump concrete.

Cubes of size 150mm x 150mm x 150mm was used for the casting. The concrete was placed in three layers and each layer was tampered 25 times with standard tamping rod. The top was levelled with the top of the mould. The surface of the concrete was smooth with a steel float and then covered with a sack and left for 24 hrs.

The cubes in mould were placed in the laboratory for 24 hrs. The concrete cubes were then strike out and placed immediately in moist curing tanks for 7, 14, 21, 28, 90 and 356 days. After each of the stated days, the cubes and was removed from the tank and allowed to dry in open air for 2 hours before being subjected to compressive strength, shrinkage and creep tests respectively.

The compressive strength of the cube sample was determined in accordance with the standard procedure given in BS 2080 (BSI, 1970). The weights of the sample were always taken before the compressive strength was determined. Four cubes samples was crushed in the 7^{th}, 14^{th}, 21^{st}, and the 28^{th} day respectively using the compressive strength machine The compressive strength was calculated using this formula

Compressive strength = $F/_{A}$

Where F = Failure load (N) and A = Cross-sectional area (mm^2).

Results and Discussion

The quality of concrete made from MSA was achieved by carrying out the preliminary tests, looking at the property of the fresh concrete and the hardened concrete made from the materials the following results and observations was obtained.

Properties of Fresh Concrete

The higher the percentage presence of MSA in the fresh concrete mix there was a change of colour from ash colour to dark, decrease in slump and flow and decrease in weight/density as shown in the table and graph.

The compressive strength of the MSA at 5% - 25% decreases as compared with the 0% as shown in the table and graph:

The weight (kg) and density (kg/m^3) is as tabulated below for various percentage replacement ratios and 7, 21 and 28 days of crushing.

Conclusion

The following conclusions were drawn from the work:

MSA can be used for replacement of OPC in concrete. The compressive strength shows that the mechanical property for the concrete even at 28days is 20N/mm2 for 25% MSA concrete. The density/weight of MSA concrete at (5 - 25)% is lower than normal concrete at 0% MSA. The workability of the concrete decreases as the percentage of MSA increases but still workable at 25% MSA but not workable at all at 30% and 35% MSA replacement.

Table.1 % Replacement, Slump and Flow of Fresh Concrete

% Replacement	Slump Test (mm)	Flow Test (mm)
100 % OPC,0 % MSA	75	430
95 % OPC,5 % MSA	64	360
85 % OPC, 15% MSA	27	320
75%OPC,25% MSA	20	300
70%OPC,30% MSA 65%OPC,35% MSA	Collapse and failed during curing in the curing tank	

Table.2 % Replacement and Compressive Strength of Hardened Concrete

% Replacement	Compressive Strength (N/mm2)		
	7days	14days	28days
100%OPC, 0% MSA	29.8	34.4	34.2
95%OPC, 5% MSA	28.9	35.8	35.1
85%OPC, 15% MSA	16	20.2	20.4
75%OPC, 25% MSA	15.6	18.9	19.6
70%OPC, 30% MSA 65%OPC, 35% MSA	Collapse and failed during curing in the curing tank		

Table.3 % Replacement, Crushing Days, Weight and Density of Hardened Concrete

% Replacement	Crushing Days	Weight (kg)	Density (kg/m^3)
	7	7.961	2359
	21	8.026	2358
0%	28	8.090	2397
	Average	**8.026**	**2378**
	7	7.980	2364
	21	8.026	2364
5%	28	8.015	2375
	Average	**8.007**	**2372**
	7	7.971	2362
	21	7.983	2365
15%	28	7.995	2369
	Average	**7.983**	**2365**
	7	7.953	2356
	21	7.953	2356
25%	28	7.926	2348
	Average	**7.944**	**2354**

Figure.1 Slump Vs % MSA for C25/30 W/C Ratio of 0.60

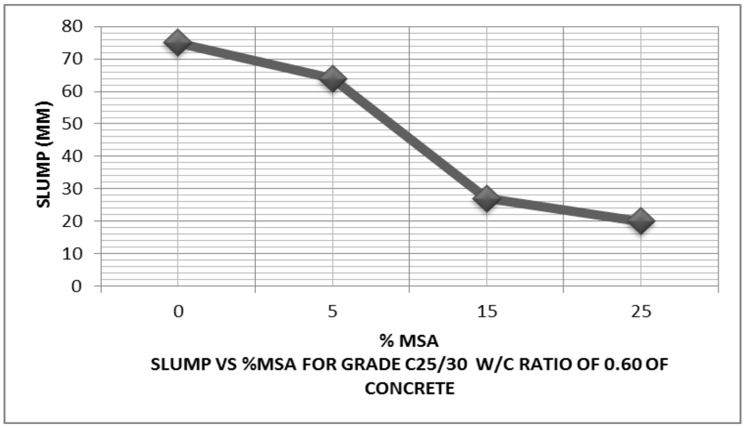


Figure.2 Flow Vs % MSA for C25/30, W/C Ratio of 0.60

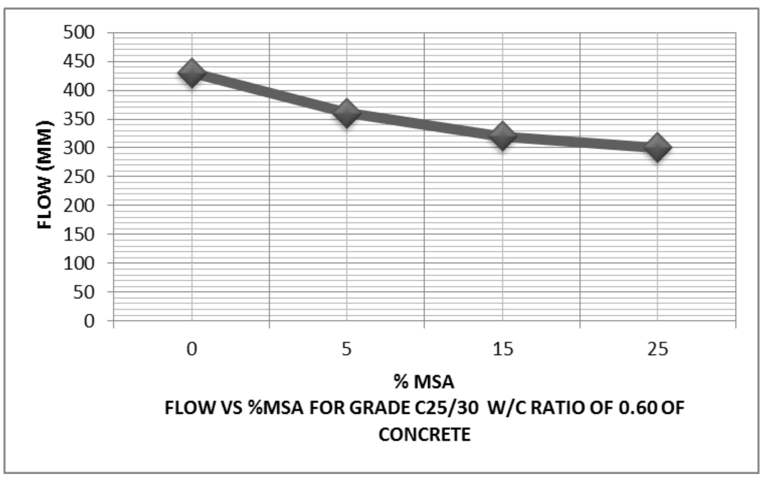


Figure.3 Strength Vs Days for 0%MSA for C25/30, W/C Ratio of 0.60

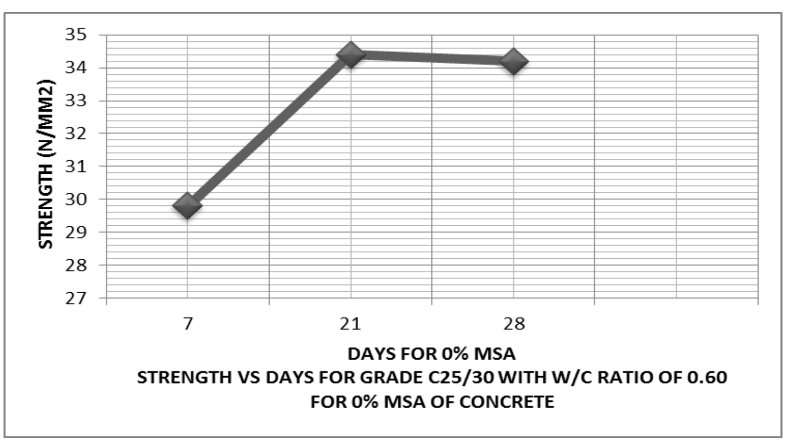


Figure.4 Strength Vs Days for 5%MSA for C25/30, W/C Ratio of 0.60

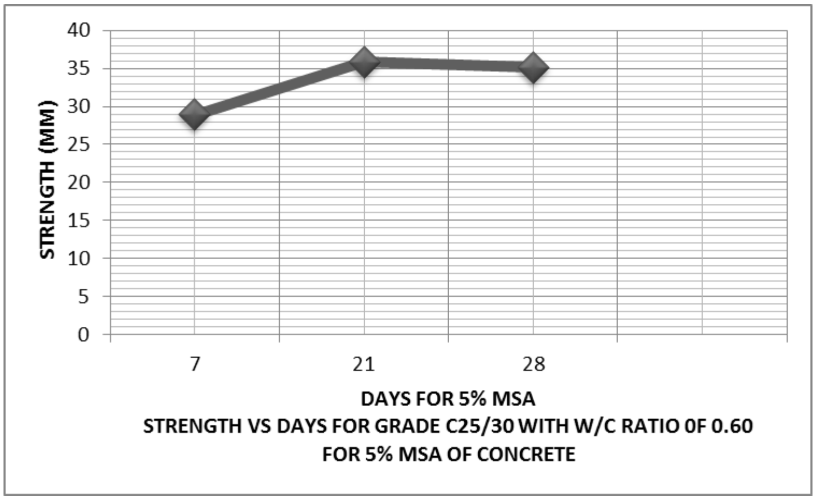


Figure.5 Strength Vs Days for 15%MSA for C25/30, W/C Ratio of 0.60

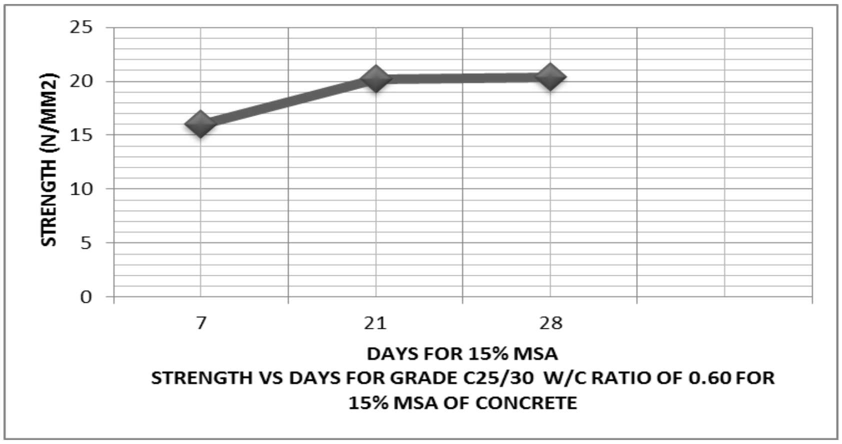


Figure.6 Strength Vs Days for 25 % MSA for C25/30, W/C Ratio of 0.60

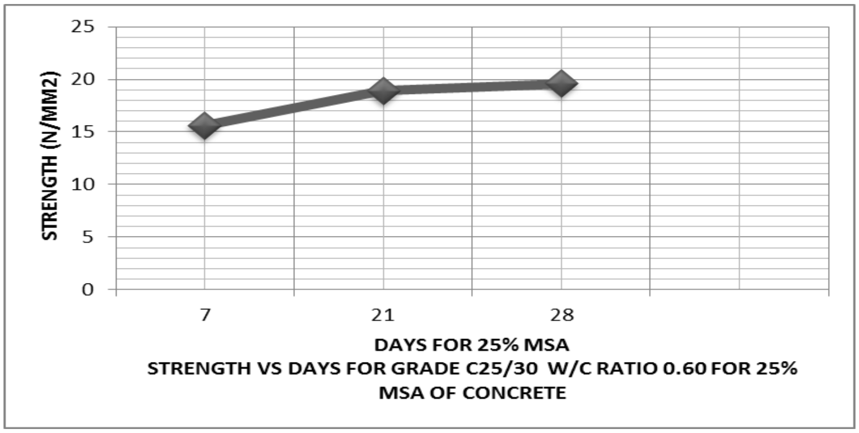


Figure.7 Weight Vs % MSA for C25/30, W/C Ratio of 0.60

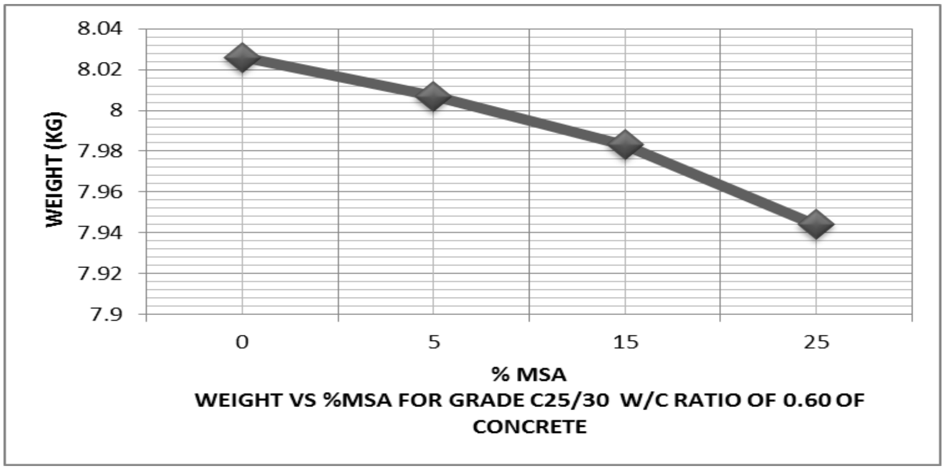
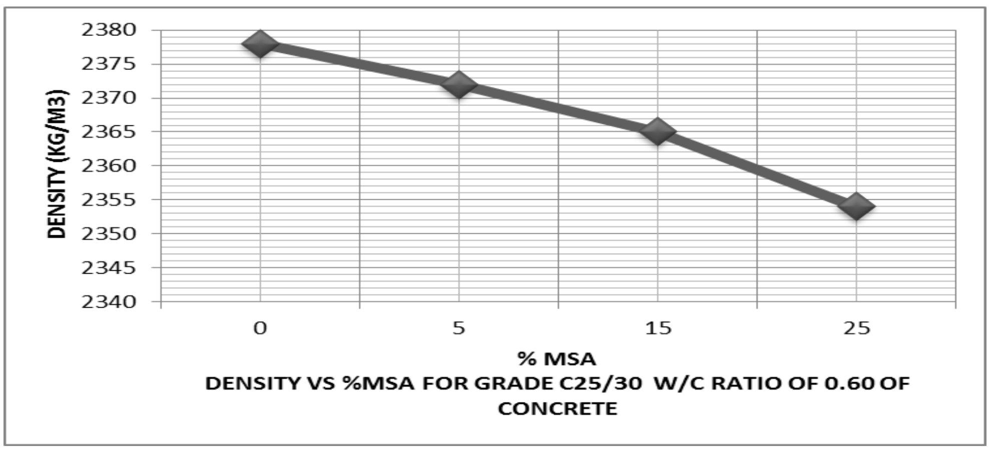


Figure.8 Density Vs % MSA for C25/30, W/C Ratio of 0.60



References

ASTM C 109, (1993). 'Standard Test Method for Compressive Strength of Hydraulic Cement Mortars'.

ASTM C 33, (1994). 'Standard Specification for Concrete Aggregates. – Annual Book of ASTM Standards'.

ASTM C 512. (1992). Standard Test Method for Creep of Concrete in Compression.

ASTM C-157, (1992). "Standard Test Method or Length Change of Hardened Hydraulic-Cement Mortar and Concrete"

ASTM C-512, (1992). "Standard Test Method for Creep in Compression".

ASTM C618, (1981). 'Specification for Fly Ash and Raw or Calcined Natural Pozzolana for Use as Mineral/Admixture in Portland cement'.

Bamidele, I. and Dahunsi, O. (2002), 'Properties of Periwinkle-Granite Concrete'. Journal of Civil Engineering, JKUAT. Vol.8, 2002. pp. 27-36.

Bazant, Z. P., Chern, J. C. (1985). Concrete creep at variable humidity: constitutive law and mechanism // Mater. Sruct.. Vol. 18. P. 1–20.

Bazant, Z.P. , Xi, Y.P. (1994). Drying creep of concrete: constitutive model and new experiments separating its mechanisms // Mater. Struct. Vol. 27, No. 165. P. 3–14.

Benboudjema, F., Meftah, F., Sellier, A., Torrenti, J. M., Heinfling, G. (2001). On the prediction of delayed strains for concrete subjected to drying and loading simultaneously // Proc. CONCREEP 6: Creep, Shrinkage and Durability Mechanics of Concrete and Other Quasi-Brittle Materials, Cambridge, USA, P. 245–250.

British Standard Institution, (1973). BS12, Ordinary and Rapidly Hardening Portland cement.

Duna S. and Mofoke A.L.E (2004). " Evaluation of some Engineering.

Elinwa A.U and Awari I.A (2001). "Groundnut Hush Ash concrete". Nigerian Journal of Engineering Management. Vol.12 No 1 pp 8-15.

El-Sayed M.A and El-Sanmi T.M (2006). "Physical and chemical properties of Rice Straw Ash and its effect on the cement paste produced from different cement types". J. King Saud University. Vol. 19, Eng.Sc (1), pp21-30.

Erdoğan, T. (2003), Concrete. – METU Press Publishing Company, Turkey,. P. 741

Falade, F. A. and Ikponmwosa, E. E. (2006), "Scope of Bamboo Reinforcement in Concrete Beams for Low-Cost Housing". Journal of Construction and Materials Technology, (NBRRI), Accepted for publication in Vol.3 No.1 -2

Ikponmwosa, E. and Falade F. (2006), "A Study on the Properties of Fibre Reinforced Laterized Concretes". Journal of Raw Materials Research, Vol.3, No.1. p46-55.

Jorge, K. Y. (2000), "An Evaluation of the Geological Potential of Pozzolanic Materials in The State of Sao Paulo". A Project Report on 'Pozzolanas: the map of the mine', Pesquisa FAPESP online magazine, Vol. 12.2000, Ed. 60. http://www.revistapesquisa.fapesp.br/novo_site/extras/

Neville, A. M. (1983), Properties of Concrete.-Pitman Publishing Ltd., London, . P. 433–528.

Obams O. And Tyagher S.T (2005). "Setting times, pozzolanicity of rice husk ash 'Cement' and its concrete compressive strength relationship with water-cement ratio". International Journal of Science and Technological Research. Vol. 2 No 1 & 2. Pp 156-159.

Okafor, F. O. (1988), "Palm Kernel Shell as a Lightweight Aggregate in Concrete". Cement and Concrete Research, vol. 18/6.0, 901-910.

Okpala O.C (1987). "Rice husk ash as a partial replacement of cement in concrete". Proceedings of Annual Conference. Nigerian Society of Engineers.

Olanipekun, E. A., Olusola, K. O. and Ata, O. (2006), "A Comparative Study of Concrete Properties Using Coconut Shell and Palm Kernel Shell as Coarse Aggregate". Building and Environment, Vol.41/3, 297-301.

Oluyemi-Ayibiowu B.D and Aderinola O.S (2007). "Evaluation of kernel shells as construction materials for low cost houses". Nigerian Journal of Engineering Management. Vol. 8 No 3 pg 10.

Osayemwen, E.O. (1992), 'An Investigation of The Characteristics of Lightweight Concrete Made of Periwinkle Shells, Palm Kernel Shells, Sand and Sawdust as aggregates'. Unpublished M.Sc. Dissertation, department of Civil

Engineering, University of Lagos, Nigeria. 1992.

Oymael, S. 1995.The Suitability of Oil Shale Ash as an Admixture in Cement and Concrete. – PhD Dissertation, Firat University, Elazig, P. 163.

Oymael, S. 2007. The effect of sulphate on lenght change of concrete // Oil Shale. Vol. 24, No. 4. P. 561–571.

Oymael, S., Durmus, A. 2006. Effects of sulphates on elastic modulus of concrete samples made from blends of cement with oil shale ash // Oil Shale. Vol. 23, No. 2. P. 125–134.

Postacıoğlu, B. 1988. The Basics of Construction Material. – Matbaa Teknisyenleri Basımevi, Istanbul.

properties of Laterite blocks made with extracts of locust beans". Nigerian Journal of Engineering Research and Development. Vol.3 No1 pg 18.

Salau M.A and Ikponmwosa E.F (2008). "Effects of partial substitute of coarse aggregate with recycled aggregate on concrete strength". N.S.E Technical Transaction Vol. 43 No 2 pp 52-66.

Salau M.A, Sadiq O.M. (2001), "Oil palm fibre strips as a substitute for steel reinforcement in concrete " NSE Technical Transactions Vol. 36, No. 2, 2001pp. 1-9.

Salau, M. A. (1997), "Partial Replacement of Ordinary Portland Cement with Pulverized Electric Arc Furnace Slag". Proceedings on Conference of Structural Engineering & modeling (SEAM 4), Ghana, Vol. 1, 272-281.

Salau, M.A and Balogun, L.A. (1988), "Shear resistance of reinforced laterized concrete beams without shear reinforcement". Building and Environmental, No.25(1): p71-76

Salau, M.A. and Ikponmwosa, E.E. (2008), "Effect of Partial Substitute of Coarse Aggregate with Recycled Aggregate on Concrete Strength". N.S.E. Technical Transactions Vol. 43 No.2 pp 52 - 66.

Salau, M.A. and Ikponmwosa, E.E. (2008), "Performance of Oil Palm Fibre as Flexural Reinforcement in Concrete Slabs". Proceedings of the International Conference on Civil Engineering Design and Construction (Science and Practice), 12 -14 Sept. 2008, Varna Free University, Varna, B ulgaria.