International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Index Copernicus Value (2013): 6.14 | Impact Factor (2014): 5.611

Influence of Water Cement Ratio Variation on Properties of Millet Stem Ash (MSA) Concrete

Oseni O. W.[1], Audu T.M.[2]

[1, 2]Department of Civil Engineering, University of Abuja, Nigeria

Abstract: ***The influence of varying the water cement ratio on the compressive strength properties of concrete are substantial factors in the design and construction of concrete structures. Compressive strength directly affects the degree to which the concrete can be able to carry load over time. These changes are complemented by deflections, cracks etc. in concrete structural elements. The purpose of this research was to measure the effect of water cement ratio on properties such as compressive strength, slump, flow and workability properties of Millet Stem Ash (MSA) mixes with OPC at 5%, 10%, 15%, 20% and 25% to form concrete and to evaluate whether they are acceptable for use in concrete structural elements. A normal concrete mix with cement at 100% (i.e. MSA at 0%) with concrete grade C25/30 that will attain an average strength of 30N/mm2 at 28days was used as a control at design water/cement ratios of 0.60 and increased to 0.65 and aggregate grading of (0.5-32) mm from fine to coarse was tested for: (1) Compressive Strength,(2) Slump and Flow Test The results and observations showed that the concrete mixes from MSA at 5% - 25% ratios could be used as a partial replacement to cement at these percentage mix ratio compared with the control concrete, an increase in the water cement ratio showed a significant decrease in the compressive strength and an increase in workability. Therefore, it is important that all concrete mixes exude acceptable design water-cement ratio for compressive strength characteristics for use in structures, water cement ratio is a significant factor.***

Keywords: Millet Stem Ash, Concrete, Water Cement Ratio, Compressive Strength

1. Introduction

The deployment of viable waste materials in concrete manufacture provide a satisfactory solution to some of the environmental concerns and problems associated with waste management in every country of the world Nigeria not an exception. Therefore the need to study the behaviour and/or properties of sustainable waste material such as Millet Stem Ash (MSA) concrete for building construction cannot be overemphasised. The performance of the entire building structure is a function of the quality of each material that constitutes the building. Consequence to the importation of most materials, the high cost of building materials both local and imported has made the ownership of house beyond the reach of most Nigerians [Madedor, 1992]. This has resulted in the shortage of accommodation in every urban settlement of the country with the attendant high cost of rent. Consequently, the use of locally produced building materials, agricultural and industrial wastes and products to construct houses has to be investigated and encouraged. The assessment for substitute uses and economic exploitation of naturally occurring local materials and agricultural or industrial wastes and products remains an important area of research interest in the drive towards the overall development of any nation. The current challenge facing the governments of most developing nations like Nigeria is how to provide good accommodation for the growing population at relatively low cost. For this research basic concrete mix of grade C25/30 and design water cement ratio of 0.60 and an increment to 0.65 was examined for:
0% MSA, 100% Cement, (0.5-32) mm fine- coarse aggregate mix concrete (Control),
5% MSA, 95% Cement, (0.5-32) mm fine-coarse aggregate mix concrete,
10% MSA, 90% Cement, (0.5-32) mm fine/coarse aggregate mix concrete,
15% MSA, 85% Cement, (0.5-32) mm fine-coarse aggregate mix concrete,
20% MSA, 80% Cement, (0.5-32) mm fine-coarse aggregate mix concrete,
25% MSA, 75% Cement, (0.5-32) mm fine-coarse aggregate mix concrete.

2. Methodology of Research

2.1 Materials

The materials used in the production of the concrete cubes are; sand, gravels, cement, millet stem ash and water. The was obtained at Gwagwalada-Abuja-FCT environs and transported to JULIUS BERGER PLC (JBN PLC), QUALITY ASSURANCE & CONTROL (QA&C) LABORATORY, Mpape-Abuja, FCT, for preliminary analysis for suitability for use in concrete.

The coarse aggregate was obtained within Gwagwalada-Abuja-FCT and transported to JBN PLC, QA&C LABORATORY, Mpape-Abuja, 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. Millet Stem is a waste product in millet farms in rural areas of FCT, Niger State and Kaduna Stated. The source of water used for this work is the borehole water situated in the JBN PLC, QA&C LABORATORY, Mpape-Abuja, FCT.

2.2 Experimental procedures

The study commence with the collection of Millet Stem from farms around Abuja -Niger-Kaduna-Zaria. The Millet Stem 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).

The following preliminary analysis tests were conducted on the materials in accordance with the various codes, to determine their suitability for concrete making: Specific Gravity Test; Aggregate impact Value Test; Silt Content Test; Moisture Content Test and Sieve Analysis Test;

Materials were batched by weight; measurement was done normally using head pan and a balance. The concrete mix was designed in accordance with the British design mix BS 8110. Mixing was done using rotary concrete mixer. The fine and coarse aggregate, cement, millet husk ash was mixed all together in the concrete mixer thoroughly to achieve the final uniformity. The required quantity of water to cement ratio of 0.60 and 0.65 was added.

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. After the third layer has been tampered, 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. The surface of the concrete was smoothen 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 then strike out and placed immediately in moist curing tanks for 7, 21, 28 and 56 days. After each of the stated days, the cubes was removed from the tank and allowed to dry in open air before being subjected to compressive strength. 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 concluded. A three cubes sample was crushed in the 7^{th}, 21^{st}, 28^{th} and 56 day respectively.

Figure 1: Slump Test

Figure 2: Flow Test

The maximum load carried by the specimen before failure occurs was recorded. The compressive strength can be calculated using this formula

Compressive strength = F/A

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

Figure 3: Cubes samples for trial mixes at different % ratio replacements

Figure 4: Compressive Strength Test Machine

3. Results and Discussions

The quality of concrete made from MSA was achieved by carrying out the preliminary tests, carrying out mix design and choosing the design water-cement ratio of 0.60 and increasing the water-cement ratio to 0.65 to see the effect on the property of the fresh concrete and the hardened concrete. The following results and observations were obtained. The higher the percentage presence of MSA in the mix there is a change of concrete colour from ash colour to dark ash, decrease in slump and flow, hence an increase in workability as shown in the table and graph.

Table 1: Slump/Flow of concrete grade C25/30 at water cement ratio of 0.60

% Replacement at water cement ratio of 0.60 and concrete grade C25/30	*Slump Test (mm)*	*Flow Test (mm)*
100%OPC, 0% MSA	75	430
95%OPC, 5% MSA	64	360
90%OPC, 10% MSA	15	260
85%OPC, 15% MSA	27	320
80%OPC, 20% MSA	20	280
75%OPC, 25% MSA	20	300
70%OPC, 30% MSA	10	100
65%OPC, 35% MSA	5	50

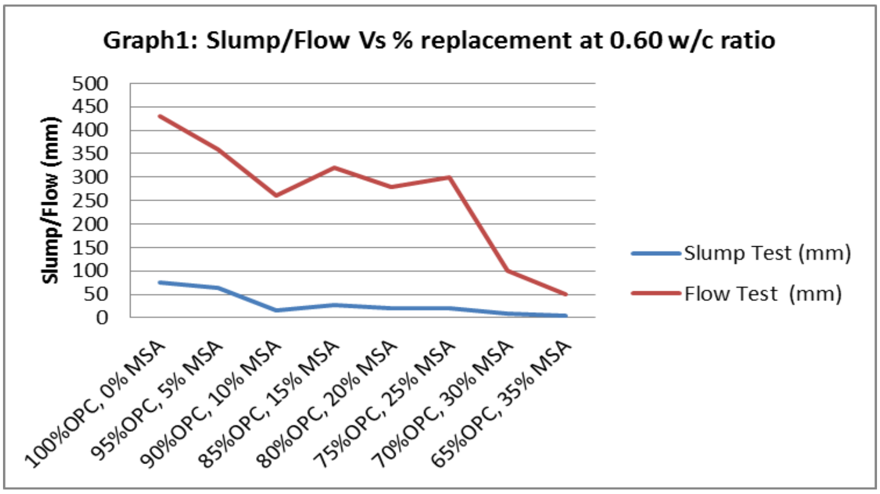
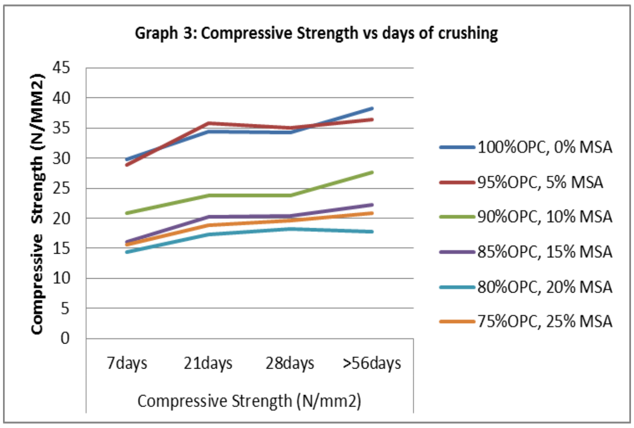


Table 2: Slump/Flow of concrete grade C25/30 at water cement ratio of 0.65

% Replacement at water cement ratio of 0.65 and concrete grade C25/30	*Slump Test (mm)*	*Flow Test (mm)*
100%OPC, 0% MSA	145	430
95%OPC, 5% MSA	195	510
90%OPC, 10% MSA	62	350
80%OPC, 20% MSA	110	420
75%OPC, 25% MSA	90	400



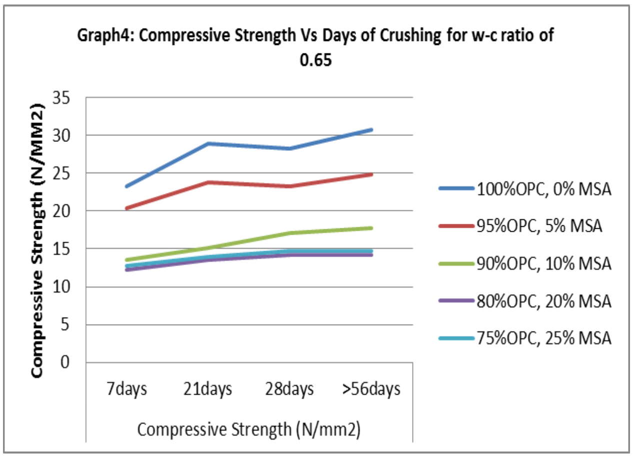
The compressive strength of the hardened concrete decreases as % replacement of MSA increases from 5% - 25% compared with the 0% MSA. The compressive strength drops by (20%-30%) with the increase in water cement ratio as shown in the table and graph:

Table 3: Compressive Strength (N/mm2) of concrete grade C25/30 at water cement ratio of 0.60

% Replacement at water cement ratio of 0.60 and concrete grade C25/30	Compressive Strength (N/mm2)			
	7 days	21 days	28 days	>56 days
100%OPC, 0% MSA	29.8	34.4	34.2	38.2
95%OPC, 5% MSA	28.9	35.8	35.1	36.4
90%OPC, 10% MSA	20.9	23.8	23.8	27.6
85%OPC, 15% MSA	16	20.2	20.4	22.2
80%OPC, 20% MSA	14.4	17.3	18.2	17.8
75%OPC, 25% MSA	15.6	18.9	19.6	20.8
70%OPC, 30% MSA	Collapsed and failed during curing in the curing tank			
65%OPC, 35% MSA				

Table 4: Compressive Strength (N/mm2) of concrete grade C25/30 at water cement ratio of 0.65

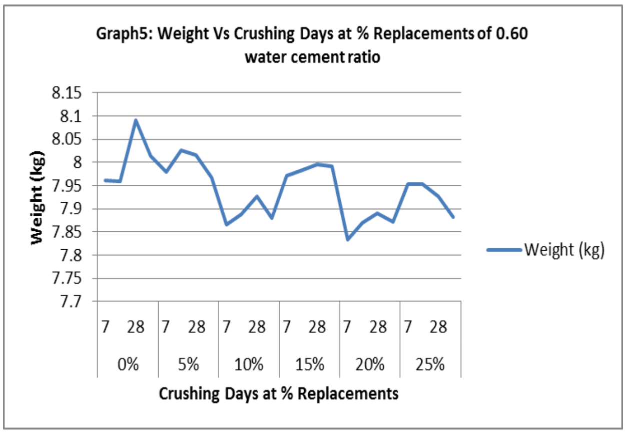
% Replacement at water cement ratio of 0.65 and concrete grade C25/30	Compressive Strength (N/mm2)			
	7 days	21 days	28 Days	>56 days
100%OPC, 0% MSA	23.3	28.9	28.2	30.7
95%OPC, 5% MSA	20.4	23.8	23.3	24.9
90%OPC, 10% MSA	13.6	15.1	17.1	17.8
80%OPC, 20% MSA	12.2	13.6	14.2	14.2
75%OPC, 25% MSA	12.7	14.0	14.7	14.7



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

Table 5: Weights (kg) and Densities (kg/m3) of concrete grade C25/30 at water cement ratio of 0.60

% Replacement at water cement ratio of 0.60 and concrete grade C25/30	Crushing Days	Weight (kg)	Density (kg/m^3)
0%	7	7.961	2359
	21	7.959	2358
	28	8.090	2397
	>56	8.014	2375
	Average	8.006	2372
5%	7	7.980	2364
	21	8.026	2378
	28	8.015	2375
	>56	7.968	2361
	Average	7.997	2370
10%	7	7.866	2331
	21	7.889	2337
	28	7.926	2348
	>56	7.880	2335
	Average	7.890	2338
15%	7	7.971	2362
	21	7.983	2365
	28	7.995	2369
	>56	7.991	2344
	Average	7.985	2360
20%	7	7.833	2321
	21	7.871	2332
	28	7.890	2338
	>56	7.873	2333
	Average	7.867	2331
25%	7	7.953	2356
	21	7.953	2356
	28	7.926	2348
	>56	7.883	2336
	Average	7.929	2349



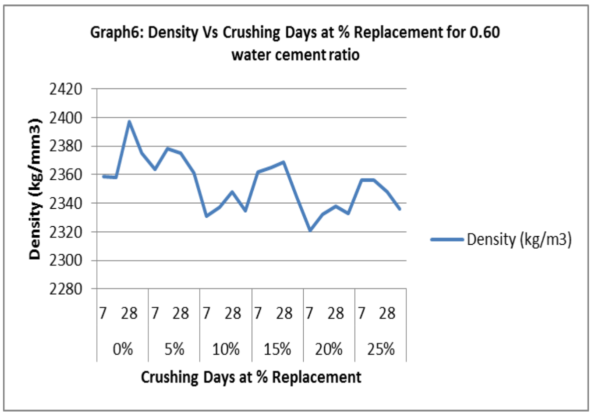
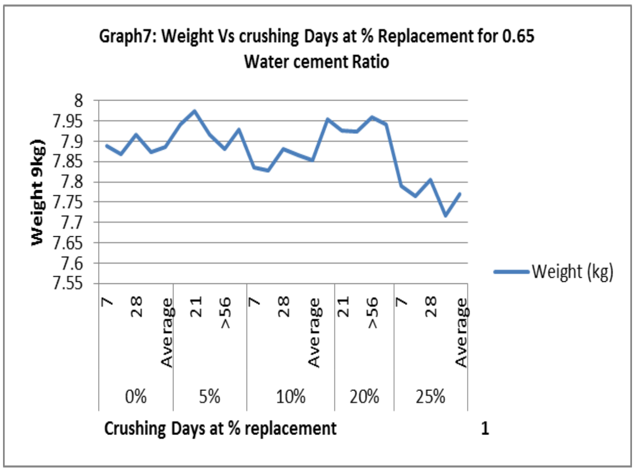
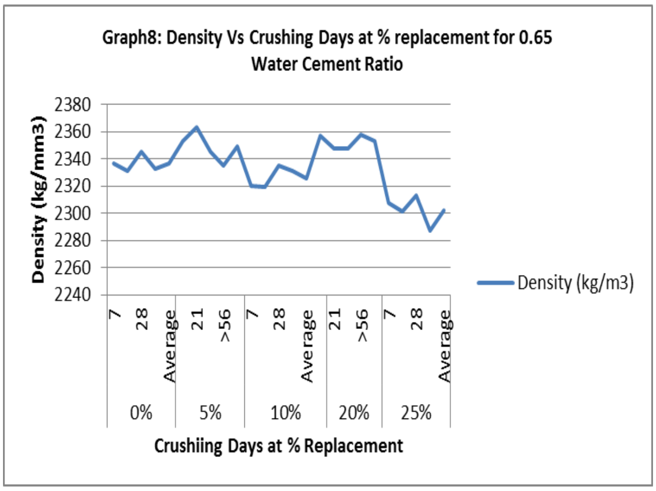


Table 6: Weights (kg) and Densities (kg/m3) of concrete grade C25/30 at water cement ratio of 0.65

% Replacement at water cement ratio of 0.65 and concrete grade C25/30	*Crushing Days*	*Weight (kg)*	*Density (kg/m^3)*
0%	7	7.889	2337
	21	7.869	2331
	28	7.916	2345
	>56	7.874	2333
	Average	7.887	2337
5%	7	7.942	2353
	21	7.974	2363
	28	7.916	2345
	>56	7.882	2335
	Average	7.929	2349
10%	7	7.836	2320
	21	7.827	2319
	28	7.882	2335
	>56	7.866	2331
	Average	7.853	2326
20%	7	7.955	2357
	21	7.926	2348
	28	7.923	2348
	>56	7.959	2358
	Average	7.941	2353
25%	7	7.790	2308
	21	7.765	2301
	28	7.806	2313
	>56	7.717	2287
	Average	7.770	2302





4. Conclusion

The result from this research shows that:

1) MSA concrete can be used for replacement of Portland cement in concrete
2) The compressive strength shows that the mechanical property for the concrete even at 28days is 20N/mm2 for 25% MSA concrete and it is influenced by the increase in water cement ratio, it reduced the compressive strength significantly to 14.2N/mm2..
3) The density of MSA concrete is lighter compared with the normal concrete at 0% MSA even with the increase in water cement ratio.
4) The workability of the concrete decreases as the percentage of MSA increases but still workable at 25% MSA replacement.

The following research as well can also be achieved in future using other results obtained during this work:

(1) Chemical characterisation of the Millet Stem Ash
(2) Morphology and microstructure of the concrete made from MSA concrete.
(3) Influence of Initial and final set time of MSA concrete.
(4) The shrinkage and creep test to determine the long term suitability of MSA concrete for structural elements in structures.

5. Recommendations

All samples MSA concrete evaluated for C25/30 and water cement ratio revealed that:

(1) MSA concrete could be used for concrete at 15% replacement at water cement ratio of 0.60 and 5% at water cement ratio of 0.65.
(2) The MSA concrete is of lighter weight and density with normal concrete at 0% but becomes lighter as % MSA increases.
(3) The workability of the MSA concrete decreases as the % MSA increases becoming unworkable at water cement ratio of 0.60 but more workable at 0.65 water cement ratio..

References

[1] American Society for Testing Materials, ASTM (1981). C618, Specification for Fly Ash and Raw or Calcined Natural Pozzolana for Use as Mineral/Admixture in Portland cement.

[2] American Society for Testing Materials, ASTM C-157 "Standard Test Method or Length Change of Hardened Hydraulic-Cement Mortar and Concrete"

[3] American Society for Testing Materials, ASTM C-512 "Standard Test Method for Creep in Compression".

[4] ASTM C 33. Standard Specification for Concrete Aggregates. – Annual Book of ASTM Standards, 1994.

[5] ASTM C 109. Standard Test Method for Compressive Strength of Hydraulic Cement Mortars, 1993.

[6] ASTM C 512. Standard Test Method for Creep of Concrete in Compression, 1992.

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

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

[9] British Standard Institution (1995). BS812, Testing Aggregates.

[10] British Standard Institution (1997). BS5328, Method of Specifying Concrete mixes..

[11] Duna S. and Mofoke A.L.E (2004). "Evaluation of some Engineering properties of Laterite blocks made with extracts of locust beans". Nigerian Journal of Engineering Research and Development. Vol.3 No1 pg 18.

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

[13] 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.

[14] 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

[15] 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.

[16] Okafor, F. O. (1988), "Palm Kernel Shell as a Lightweight Aggregate in Concrete". Cement and Concrete Research, vol. 18/6.0, 901-910.
[17] Okpala O.C (1987). "Rice husk ash as a partial replacement of cement in concrete". Proceedings of Annual Conference. Nigerian Society of Engineers.
[18] 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.
[19] 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.