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Performance of Millet Husk Ash in Self Compacting Concrete

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Abstract

In a quest to mitigate the negative effects associated with the use of high cement content in self-compacting concrete (SCC), mineral additive from agricultural waste of millet husk ash (MHA) was explored with a view to partially replace cement in SCC without loss of quality. Several trial mixes were carried out with the aim of achieving grade 40 SCC, using water to binder ratio of 0.35 and plasticizer at 1.05 litre per 100 kg of cement. The adopted mix proportion satisfying the desired strength was used in production of MHA concrete (SCC – MHA) containing 5, 10, 15, 20, 25 and 30 percentages by weight of MHA as a replacement of cement respectively. Slump flow, L-box height ratio and segregation resistance were used to evaluate the fresh properties of the SCC – MHA mixes and compressive, splitting tensile and flexural strengths of the SCC – MHA evaluated at 3, 7, 28, 56 and 90 days curing ages were used to study the effects of the MHA in SCC. The result from the study shows that the slump flow and passing ability of the fresh SCC – MHA reduces with increase in MHA content in SCC but with improvement in the resistance against segregation. In addition, the increase in MHA content in SCC from 10 to 30 % reduces the compressive, splitting tensile and flexural strengths of the SCC – MHA. A microstructure study conducted on some selected specimen using X-Ray diffraction and scanning electron microscopy revealed that the available portlandite in the SCC were gradually consumed in the presence of MHA as the curing age increases. However, the result from the study showed that the MHA is class N pozzolanic material with optimum usage dose of 5 % for improvement of the hardened properties of SCC.

Keywords: Millet husk ash; Self-compacting concrete; Fresh property; Compressive strength; Splitting tensile strength

1.0 INTRODUCTION

Self-compacting concrete (SCC) is described as a concrete which in its state of homogeneity flows due its self-weight to fully fill formwork, even in the presence of congested reinforcement without the requirement of vibration (Mohamed, 2013 and Awang*et al.*, 2016). SCC as compared to conventional concrete of similar properties are more durable, has higher compressive and bond strength (Kapoor, 2012). In addition, SCC has the advantage of reducing labour cost, construction time, quality improvement and good finished surface. These advantages make it superior to conventional concrete. However, SCC relies on the use of very high content of cement paste which is associated to a number of challenge including increased cost of concrete material and the likely increase in production of cement that lead to increase emissions of carbon (IV) oxide (CO_2) which has adverse effects to the environment. Studies have shown that cement production contributes approximately 8.0 % of the global CO_2 emissions (Rodgers, 2018). In addition, higher consumption of Portland cement in SCC mix results in increasing heat of hydration and high autogenous shrinkage (Sabet*et al.*, 2013). However, cement production and its utilization can be reduced by employing of mineral additives in SCC and consequently, reduction of emission of CO_2, heat of hydration and autogenous shrinkage (Awang*et al.*, 2016). These notable effects however, are likely to be reduced by utilization of mineral additives in SCC.

There have been extensive studies on the use of mineral additives such as rice husk ash (Habeeband Fayyadh, 2009; Atan and Awang, 2011; Aboshio*et al*, 2018), fine limestone powder (Felekoglu, 2007; Ye *et al*, 2007; Esping, 2008), pulverized-fuel ash (Sukumar*et al.*, 2008; Liu, 2010; Siddique, 2011), silica fume (Yazici, 2008; Gesoglu*et al.*, 2009; Turkel and Altuntas, 2009) among others which indicate the potential of the mineral admixture to yield the needed outcome.

To this effect, the millet husk ash (MHA) which is an agricultural waste-based admixture is being considered in this study. About 29.851 million tons of millet is

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produced globally in 2018 out of which 7 % is produced in Nigeria (IPAD, 2021). Millet is a cereal food produced widely in West Africa; especially Nigeria and was rated the second largest producer of millet in the world (Worldatlas, 2017). Generally, about 40 % of the weight of the harvested millet is removed as husk from the stalk harvested (Akande, 2002). Researches into the use of millet husk ash in concrete show that the ash is pozzolanic in nature (Jimoh*et al*, 2013) and can be used as partial replacement of cement to improve the properties of concrete (Uche*et al.*, 2012). The findings of Auta*et al.*, (2015) shows that, 10 % or less of MHA can be used as replacement in normal concrete (NC). The finding of Jimoh*et al.*, (2013) also shows that up to 10 % MHA can be used to improve NC blended with lateritic soil. However, limited or no information is available on utilization of MHA in SCC. Hence, this study seeks to understand the effect of MHA in SCC.

2.0 MATERIALS AND METHODS

2.1 Materials

2.1.1 Cement

Portland Limestone Cement (CEM II/A-L) of grade 42.5 N manufactured by BUA, Nigeria was used in this study. The oxide composition and physical properties of the cement is presented in Table 1 and 2.

2.1.2 Millet husk ash (MHA)

The millet husk was collected from a dump site around a farmland in Kano State, Nigeria and burned to ash at controlled temperature of 700 ˚C for 4 hours to produce amorphous silica. Similar burning temperature was adopted by Abdulwahab*et al*, (2017) during production of MHA. The ash was then cooled and sieved through 75 μm for use in the SCC. The oxide composition, physical properties and the grading of MHA are presented in Table 1 and 2 and Figure 1 respectively. The result as presented in Table 1 shows that the combined (SiO_2 + Al_2O_3 + Fe_2O_3) oxides is more than 70 %, hence, satisfied the recommended limit given in ASTM C618 (2005) for Class N pozolana. This suggests that the MHA is a good pozzolanic material as also reported by Abdulwahab*et al* (2017), Jimoh, *et al* (2013) and Mohammed and Aboshio (2020).

2.1.3 Aggregates

Clean river sand with fineness modulus of 2.57, specific gravity of 2.61 and bulk density 1569 kg/m^3 was used for the study as fine aggregate. The particle size distribution of the fine aggregate was presented in Figure 1. While on the other hand, crushed granite rock with maximum size of 14 mm as shown in Figure 1 was used as the coarse aggregate. The coarse aggregate has fineness modulus, specific gravity and bulk density of 6.53, 2.74 and 1661 kg/m^3 respectively as was presented in Table 2. The tests on aggregates were carried out in accordance with BS EN 12620 (2013) specifications.

Table 1: Oxide Composition of Cement and MHA

Oxides	Cement	MHA
SiO_2	12.01	64.22
Al_2O_3	3.03	3.71
Fe_2O_3	4.14	3.49
CaO	74.06	6.55
MgO	1.4	2.81
SO_3	2.05	1.56
Na_2O	-	0.86
K_2O	1.27	6.01
P_2O_5	-	4.06
Cl	0.1	1.05
TiO_2	0.33	0.71
Cr_2O_3	-	
Mn_2O_3	-	0.09
ZnO	-	0.09
SrO	0.49	0.06
LoI	1.04	4.54

Table 2: Physical Properties of Binders and Aggregates

	Cement	MHA	Fine Aggregate	Coarse Aggregate
Specific Gravities	3.16	2.21	2.61	2.74
Fineness (Retained on 45 μm sieve)	13	29	-	-
Fineness modulus	-	-	2.57	6.53
Bulk Density (kg/m^3)	1446	1101	1569	1661

2.1.4 Superplasticizer

To improve fresh properties of the SCC, Conplast SP430 branded Super plasticizer was used in this research. The super plasticizer is a chloride free, super plasticizing and water reducing admixture. It was produced based on selected sulphonated naphthalene polymers which give water reductions up to 25% without loss of workability (Fosroc, 2014). 1.05 litre/100 kg of cement was used for this study. This is within the specified limit provided by the manufacturer (0.5 – 2.0 Litres/100 kg of cement).

2.1.5 Water

Potable water available in the storage tank within the Civil Engineering Laboratory of Bayero University, Kano, Nigeria was used for mixing and curing the SCC.

2.2 Methods

2.2.1 Mix design of self-compacting concrete

The principle for the selection and proportioning of SCC constituents was based on guidelines laid out in BS EN 206 (2013). The SCC of grade 40 considered in this study was achieved by trial mixes for the control (SCC without MHA) using 0.35 water – cement ratio. The control mix was used for the other SCC mixes containing 5, 10, 15, 20, 25 and 30 percentages by weight of MHA in replacement of cement. The constituent materials for the SCC – MHA are presented in Table 3.

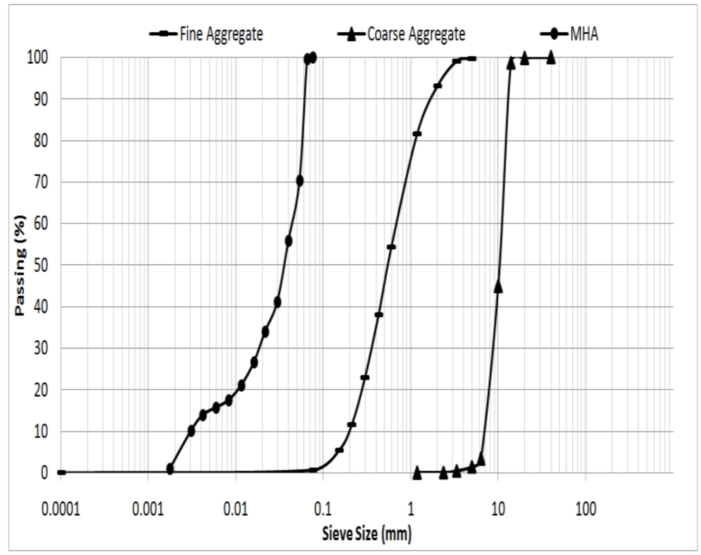

Figure 1: Grading of Aggregates and Millet Husk Ash

Table 3: Material Batching for Self Compacting – Millet Husk Ash Concrete

Mix No	% MHA	Cement (kg/m^3)	Sand (kg/m^3)	Granite (kg/m^3)	MHA (kg/m^3)	Water (kg/m^3)	Super Plasticiser (l/m^3)
Mo	0	520	860	900	0	182	5.46
M1	5	494	860	900	24.7	182	5.46
M2	10	468	860	900	46.8	182	5.46
M3	15	442	860	900	66.3	182	5.46
M4	20	416	860	900	83.2	182	5.46
M5	25	390	860	900	97.5	182	5.46
M6	30	364	860	900	109.2	182	5.46

2.2.2 Fresh properties assessment of self-compacting – millet husk ash concrete

Assessment of the self-compacting – millet husk ash concrete in its fresh state was based on the following tests: slump flow, passing ability (L-box) and segregation resistance. The tests were conducted in accordance with BS EN 12350-8, 10, 11 (2000).

2.2.3 Hardened properties assessment of self-compacting – millet husk ash concrete

Assessment of the self-compacting – millet husk ash concrete in its hardened state was based on the following tests: compressive, flexural and splitting tensile strengths. The tests were carried out in accordance to BSEN 12390-3, 5, 6 (2000) at curing ages of 3, 7, 28, 56 and 90 days. The compressive strength test was carried on 100 mm diameter and 200 mm height concrete cylinders using ELE digital compression machine at a loading rate 5 kN/s. The flexural strength using two points loading method was assessed using rectangular prism 500 x 100 x 100 mm. The splitting tensile strength was measured using 100mm diameter and 200mm length cylinders. The flexural and splitting tensile strength tests were conducted using Avery Denison Universal testing machine at a loading rate 0.4kN/s.

2.2.4 Micro Structure

The scanning electron microcopy (SEM) and X-Ray Diffraction (XRD) `studies were carried out in Biology Department of Umaru Musa Yar'adua University of Katsina, Katsina State, Nigeria. The SEM and XRD studies were carried out for the fractured surface of some selected tested specimens. Visual study of the scanned specimens was carried out to ascertain the distribution of minerals from XRD test of the specimens.

3.0 RESULTS AND DISCUSSION

3.1 Slump flow

The slump flow of SCC at 0, 5, 10, 15, 20, 25 and 30 percentages respectively by weight of MHA replacement of cement for mix M0, M1, M2, M3, M4, M5 and M6 is presented in Figure 2.

From the result in Figure 2, it can be seen that the slump flow reduces with increase in MHA content where it reduces by 5 %, 12 %, 19 %, 27 %, 31 % and 33 % of the control mix (Mo) for M1, M2, M3, M4, M5 and M6 respectively. Consequently, only M0, M1, M2, M3 and M4 satisfy the design requirement given in BS EN 12350-8, (2000). The reduction in slump flow of SC – MHA concrete at constant water – binder ratio could be attributed to the water requirement of large volume of MHA which displaces equal weight but lower volume of cement in the mixes. In addition, the reduction could also be attributed to the water absorption of MHA causing reduction in fluidity of SC – MHA concrete. The high demand for water as the MHA content increases could also be due to increased amount of silica for MHA in the mixture as compared to that of the ordinary Portland cement. This observation is similar to the finding of Obilade (2014) working on rice husk ash as partial replacement for cement in concrete.

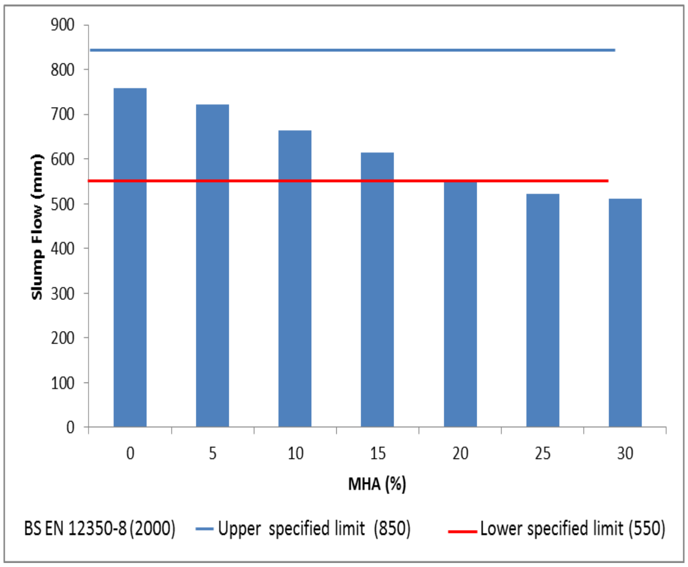

Figure 2: Variation of Slump Flow for increasing Millet Husk Ash Content in Self-Compacting Concrete

3.2 Passing ability

Result of the passing ability of SC – MHA concrete is presented in Figure 3 for M0, M1, M2, M3, M4, M5 and M6 mixes respectively. The result show passing ability reduction of 6 %, 8 %, 11 %, 13 %, 20 % and 26 % of the control mix (M0) for M1, M2, M3, M4, M5 and M6 respectively. Out of all the mix presented in Figure 3, only M0, M1 and M2 satisfied the design requirement presented in BS EN 12350-10, (2000). The reduction of passing ability could be attributed to the reduction in slump flow as MHA content increased in the SCC.

3.3 Segregation resistance

The results of the segregation resistance for all mixes are presented in Figure 4 which shows steady increase in segregation resistance as the MHA content increased. The increase in the segregation resistance could be attributed to the reduction in fluidity of SC – MHA concrete due to increasing volume of MHA content at constant water – binder ratio. However, all mixes satisfied the BS EN 12350-11, (2000) requirement (≤ 15 %) as presented earlier in Table 2.

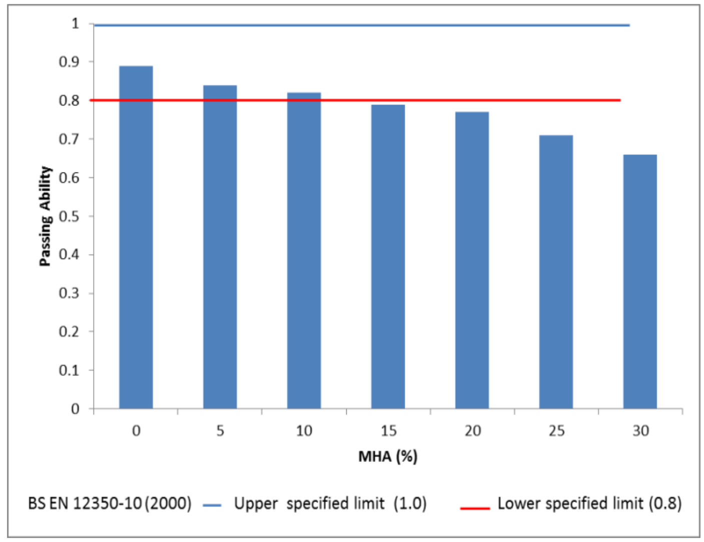

Figure 3: Variation of Passing Ability for increasing Millet Husk Ash Content in Self-Compacting Concrete

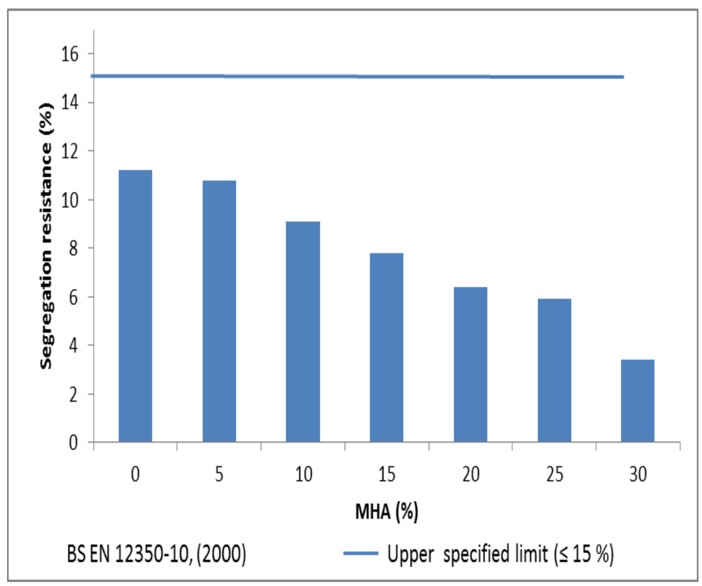

Figure 4: Variation of Segregation Resistance for increasing Millet Husk Ash Content in Self-Compacting Concrete

3.4 Compressive strength

The compressive strength of SC – MHA concrete is presented in Figure 5. The curve shows that the compressive strength decreased with increase in MHA content respectively. However, the decrease in compressive strength of SC – MHA concrete from 39 – 29 N/mm^2 at 28 days curing age was noted at MHA content beyond 5 % which amount to 66.7 – 89.7 % compressive strength of control specimen, with least compressive strength at 30 % MHA content (M7). This trend is similar to the work of Auta*et al*(2015) on MHA in normal weight concrete.

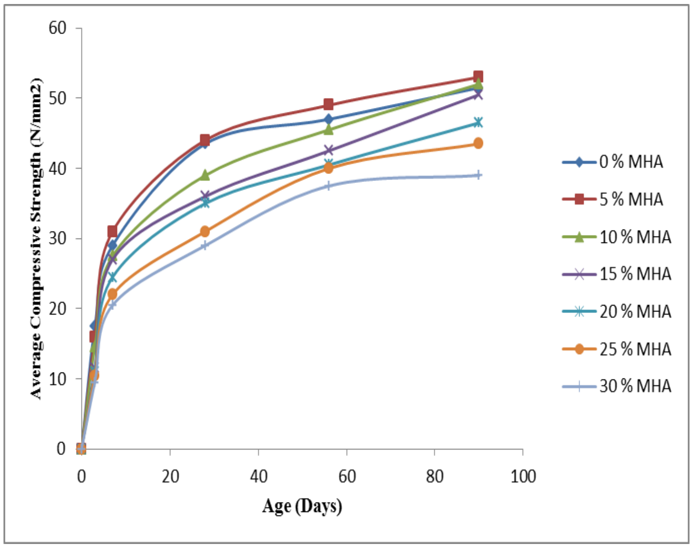

Figure 5: Compressive Strength of Self-Compacting Concrete modified with Millet Husk Ash

The reduction in the compressive strength of SCC – MHA concrete above 5 % MHA content could be as a result of increasing unreactive excess MHA content in the mixes. This implies that the MHA content is more than the quantity required to liberate lime during the process of hydration and hence leading to excess silica leached out of the concrete. In addition, for constant water/binder ratio, the reduction in flow of SCC with increase in MHA content reduced compaction of SCC which may result in reduction in strength of the SC – MHA concrete. This observation was earlier presented in Section 3.1.1 on effects of MHA on fresh properties. The 28 days compressive strength of SC – MHA concrete with up to 5 % MHA content (44 N/mm^2) exceeded the control and design strength of 43.5 N/mm^2 and 40 N/mm^2 respectively as observed from Figure 5. Same dose (5 %) was reported by Uche*et al* (2012) as the optimum for MHA in normal weight concrete. The improvement in strength could be as a result of pozzolanic reaction where calcium hydroxide (CH) products are reduced by silicon oxide (SiO_2) from MHA which yielded more calcium silicate hydrate (CSH) product. This reaction continues with curing age leading to formation of a dense CSH product (improved strength) at 90 days as shown in Figure 6 – 12 following XRD and SEM tests carried out on the samples. The formation of CSH could be described as a product pozzolanic reaction as SiO_2 convert the excess CH products.

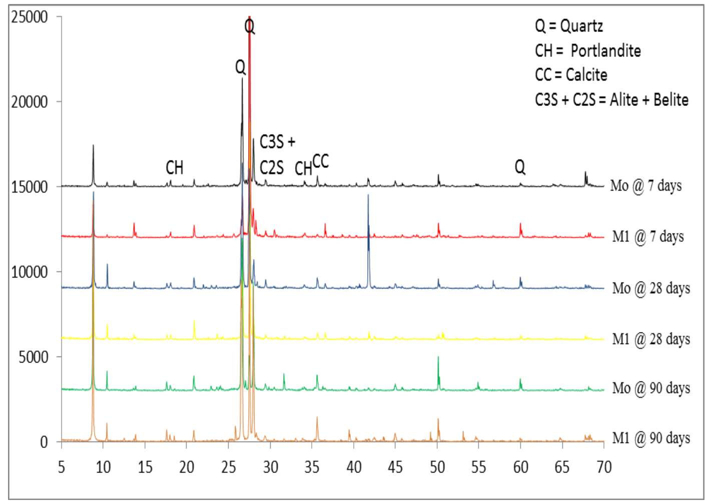

Figure 6: XRD Pattern for Self-Compacting Concrete modified with 5 % Millet Husk Ash as Replacement of Cement

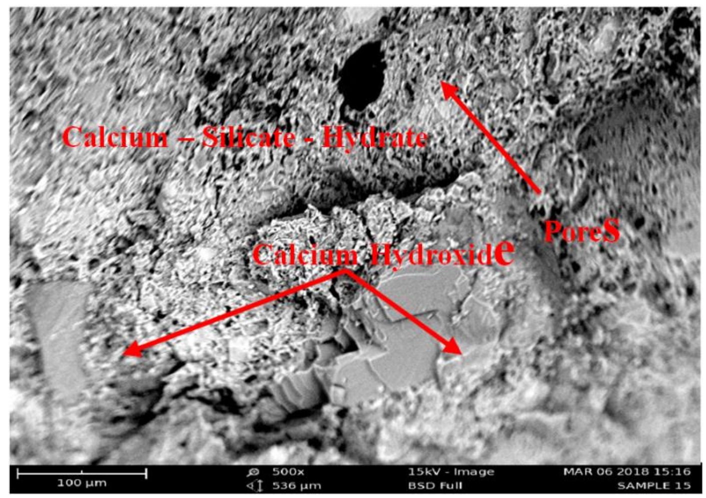

Figure 7: Scanning Electron Micrograph of Control Sample (0 % Millet Husk Ash) of Self Compacting Concrete at 7 days Curing Age

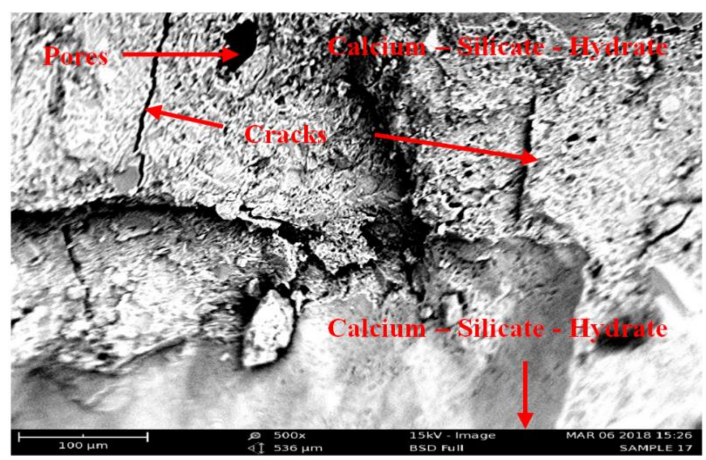

Figure 8: Scanning Electron Micrograph of Control Sample (0 % Millet Husk Ash) of Self Compacting Concrete at 28 days Curing Age

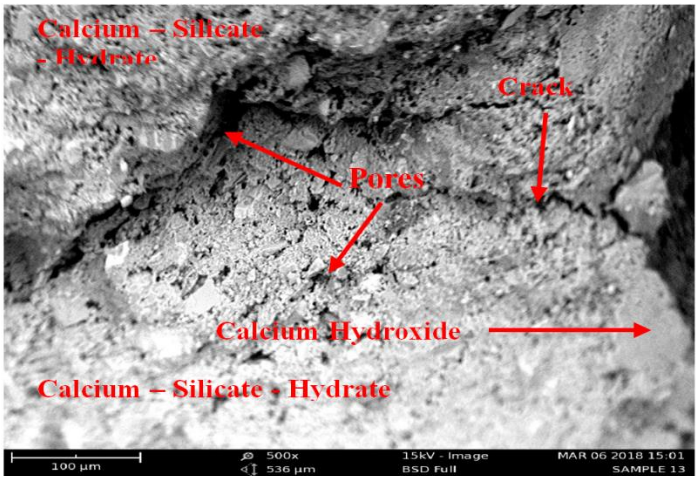

Figure 9: Scanning Electron Micrograph of Control Sample (0 % Millet Husk Ash) of Self Compacting Concrete at 90 days Curing Age

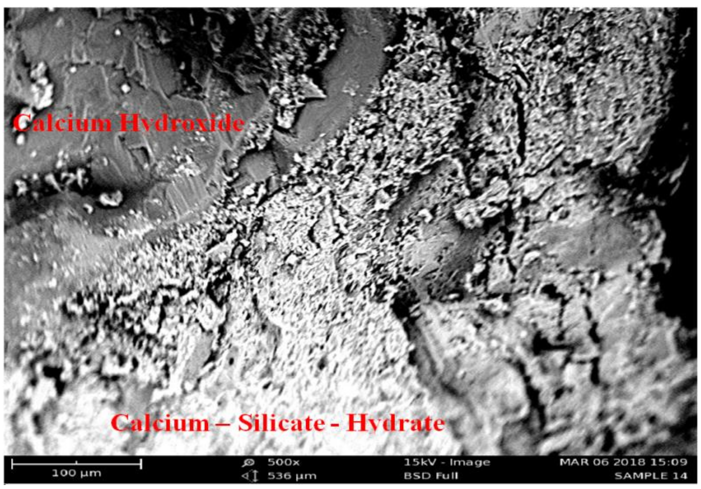

Figure 10: Scanning Electron Micrograph of Self Compacting Concrete Specimen containing Optimum Millet Husk Content Sample (5 % Millet Husk Ash) at 7 days Curing Age

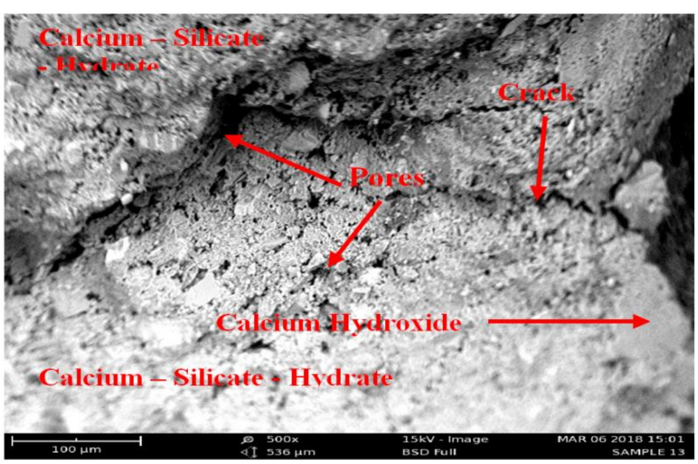

Figure 11: Scanning Electron Micrograph of Self Compacting Concrete Specimen containing Optimum Millet Husk Content Sample (5 % Millet Husk Ash) at 28 days Curing Age

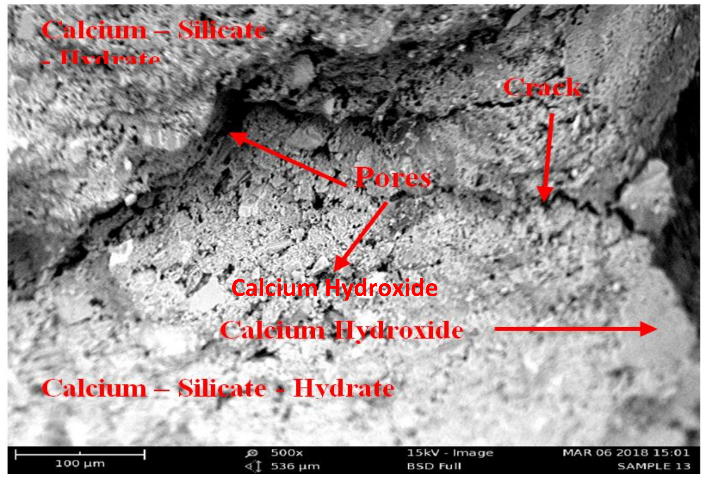

Figure 12: Scanning Electron Micrograph of Self Compacting Concrete Specimen containing Optimum Millet Husk Content Sample (5 % Millet Husk Ash) at 90 days Curing Age

3.5 Splitting tensile strength

The splitting tensile strength of SC – MHA concrete is shown in Figure 13. The result shows that the SC – MHA concrete splitting tensile strength increases with increase in curing age. This could be as a result of modification of the bonding properties of the binders' hydrates. However, at early curing age, the splitting tensile strength reduces with increase in MHA content as shown in the figure. The reduction in splitting tensile strength could be attributed to dilution effect of Portland cement and weaker formation of C-S-H gel as a result of pozzolanic reaction of excess MHA with cement. However, the splitting tensile strength of SC – MHA concrete at 5 % MHA content was higher than control at curing age of 28 days and beyond and at 10 % MHA content at 56 and 90 days. The enhancement in tensile strength at 5 and 10 % MHA content could be due to increased pozzolanic reaction of the cement particles and MHA.

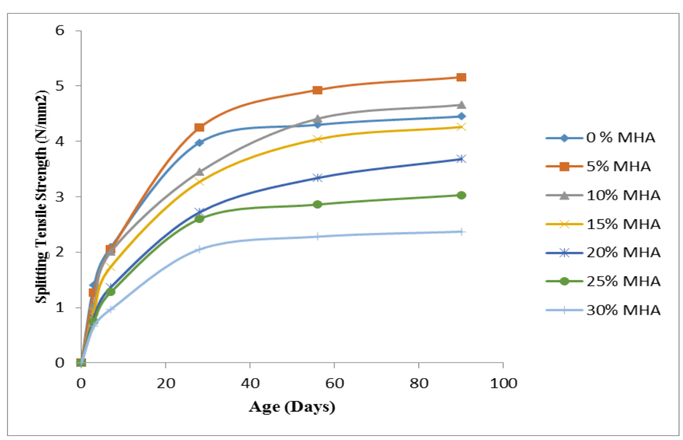

Figure 13: Splitting Tensile Strength of Self-Compacting Concrete modified with Millet Husk Ash

3.6 Flexural strength

The flexural strength of SC – MHA concrete increased with increase in curing age but decreased with increase in MHA content as shown in Figure 14. However, the flexural strength of SC – MHA concrete at 5 % MHA content was higher than that of control samples (0 % MHA) at curing ages of 28 and above. This increase was also observed in SC – MHA concrete with 10 % MHA content at 90 days of curing age. The improvement in flexural strength of SC – MHA concrete may be attributed to increased pozzolanic reaction and the packing ability of the fine particles of MHA. The decrease in flexural strength with increase in MHA content at higher MHA content above 5 % may be attributed to formation of weaker C-S-H gel as a result of increasing unreactive MHA leached out.

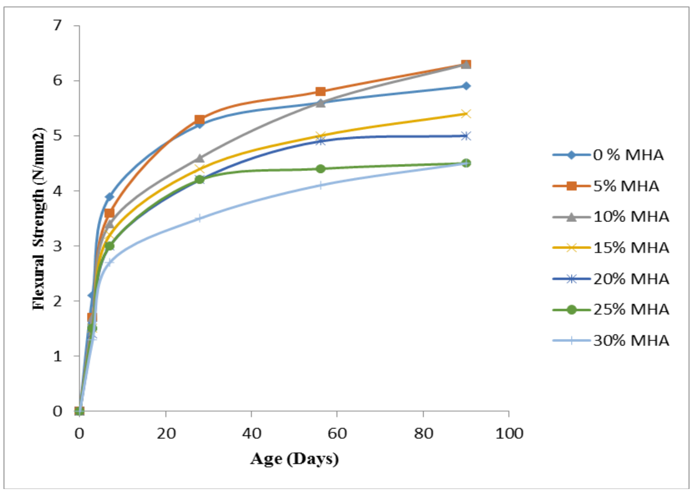

Figure 14: Flexural Strength of Self-Compacting Concrete modified with Millet Husk Ash

4.0 CONCLUSIONS

Based on the study conducted to evaluate the properties of millet husk ash in self-compacting concrete, the following conclusions are drawn.

1. Millet Husk Ash (MHA) satisfies the minimum requirement for class N pozzolana as recommended by ASTM C618.
2. Up to 10 % MHA replacement of cement by weight in SCC satisfied all the requirement for fresh properties of a concrete as provided by BS EN 12350 (2010).
3. Grade 40 SCC can be satisfactorily produced using 5 % MHA (optimum MHA content) replacement of cement by weight.
4. The splitting tensile strength and flexural strength of MHA-SCC decreased with increase in MHA content beyond 5 % MHA content.

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REFERENCES

[1] Abdulwahab, M. T., Uche, O. A. U. and Suleiman, G. “Mechanical Properties of Millet Husk Ash Bitumen Stabilized Soil Block”. *Nigerian Journal of Technological Development*, 14(1), 2017, pp 34 – 38.

[2] Aboshio, A., Shuaibu, H. G. and Abdulwahab, M. T. “Properties of Rice Husk Ash Concrete with Periwinkle Shell as Coarse Aggregates”. *Nigerian Journal of Technological Development*, 15(2), 2018, pp 33 – 38.

[3] Akande A. B. “Economic Analysis of the Relationship between Drought and Millet Production in the Arid Zone of Nigeria: A Case Study of Borno and Yobe State”, *Journal of Agriculture and Social Science*s, 2(3), 2002, pp. 112- 121.

[4] ASTM Specification “Chemical and Physical Specification”. *The American Society for Testing and Materials (ASTM)*, C618-92, 2005.

[5] Atan M. N. and Awang H. “The Compressive and Flexural Strengths of Self Compacting Concrete using Raw Rice Husk Ash”. *Journal of Engineering, Science and Technology*, 6(6), 2011, pp. 720 – 732.

[6] Auta, S. M., Shiwua, A. J. and Tsodo, T. Y. “Compressive strength of concrete with millet husk ash (MHA) as partial replacement of cement”. *Magazine of Civil Engineering*, 7, 2015, pp. 74 – 79.

[7] Awang H., Atan M. N., ZainulAbidin N. and Yusof N. “A Cost-Reduction of Self - Compacting Concrete Incorporating Raw Rice Husk Ash” *Journal of Engineering Science and Technology*. 11(1), 2016, pp. 96–108.

[8] BS EN 206. “Additional Rules for Self-compacting concrete (SCC)”. *British Standards publication*, 2013.

[9] BS EN 12350-8, “Testing fresh concrete — Part 8: Self-compacting concrete - Slump-flow test”. *British Standard Institution London*, 2000.

[10] BS EN 12350-10, “Testing fresh concrete: Self-compacting concrete - L box test”, *British Standard Institution London*, 2000.

[11] BS EN 12350-11, “Testing fresh concrete: Self-compacting concrete - Sieve segregation test. *British Standard Institution London*, 2000.

[12] BSEN 12390-3, "Testing hardened concrete: Compressive strength of test specimens". *British Standard Institution London*, 2000.

[13] BSEN 12390-5, "Testing hardened concrete: Flexural strength of test specimens". *British Standard Institution London*, 2000.

[14] BS EN 12390-6, "Testing hardened concrete: Tensile splitting strength of test specimens". *British Standard Institution London*, 2000.

[15] BS EN 12620 "Aggregates for concrete" *British Standard Institution London*, 2013.

[16] Esping, O. "Effect of Limestone Filler BET (H_2O)-area on the Fresh and Hardened Properties of Self Compacting Concrete". *Cement and Concrete Research*,38, 2008, pp 938-944.

[17] Felekoglu, B. "Utilisation of High Volumes of Limestone Quarry Wastes in Concrete Industry (Self-Compacting Concrete Case)". *Resources, Conservation and Recycling*, 51, 2007, 770-791.

[18] Fosroc Conplast SP430. "Fosroc Limited Drayton Manor Business Park Coleshill Road", Tamworth, Staffordshire B78 3XN. UK, 2014.

[19] Gesoglu, M., Guneyisi, E. and Ozbay, E."Properties of Self Compacting Concretes made with Binary, Ternary, and Quaternary Cementitious Blends of Fly Ash, Blast Furnace Slag, And Silica Fume". *Construction and Building Materials*, 23(5), 2009, pp. 1847-1854.

[20] Habeeb, G.A. and Fayyadh, M.M. "Rice husk ash concrete: the effect of RHA average particle size on mechanical properties and drying shrinkage". *Australian Journal of Basic and Applied Sciences*. 3(3), 2009, pp 1616-1622.

[21] "IPAD Millet Explorer". *International Production Assessment Division (IPAD)*, Foreign Agricultural Service, U.S. Department of Agriculture, 2021.

[22] Jimoh. R. A., Banuso. O. R. and Oyeleke. F. M. Exploratory assessment of strength characteristics of millet husk ash (MHA) blended cement laterized concrete. *Advances in Applied Science Research*, 4(1), 2013, pp 452-457.

[23] Kapoor, Y. P. Self-Compacting Concrete; An Economical Approach. *The Masterbuilder*, 2012.

[24] Liu, M. "Self-Compacting Concrete with different levels of Pulverized Fuel Ash". *Construction and Building Materials*, 24(7), 2010, pp. 1245-1252.

[25] Mohammed, A and Aboshio, A. "Exploratory Use of Agricultural Wastes for Environmental Cleansing: A Review on Concrete". *Proceedings of the 2020 Sustainable Engineering & Industrial Technology Conference*. Faculty of Engineering, UNN, 6 – 10 July 2020.

[26] Mohamed Y. "Development of Carbon Fiber Reinforced Self-Consolidating Concrete Patch for Repair Applications". Master thesis, Department of Civil Engineering, University of Waterloo, Ontario, Canada, 2013.

[27] Rodgers, L. "Climate Change: The Massive CO2 Emitter you may not know about". BBC News of 17th December 2018.

[28] Siddique, R. "Properties of self-compacting concrete containing class F fly ash". *Materials and Design, Science Direct*, 32, 2011, pp 1502-1507.

[29] Sukumar, B., Nagamani, K. and Raghavan, R. S. "Evaluation of strength at early ages of self-compacting concrete with high volume fly ash," *Construction and Building Materials*, 22(7), 2008, pp 1394-1401.

[30] Turkel, S. and Altuntas, Y. "The effect of limestone powder, fly ash and silica fume on the properties of self-compacting repair mortars". *Sadhana (India)*, 34(2), 2009, pp 331-343.

[31] Uche, O. A. U. Adamu, M. and Bahuddeen, M. A. "Influence of Millet Husk Ash (MHA) on The Properties of Plain Concrete". *Epistemics in Science, Engineering and Technology*, 2(2), 2012, pp 68-73.

[32] Worldatlas, The Leading Millet Producing Countries in the World. Updated on; April 25, 2017

[33] Yazici, H. "The effect of silica fume and high-volume Class C fly ash on mechanical properties, chloride penetration and freeze–thaw resistance of self-compacting concrete". *Construction and Building Materials*, 22(4), 2017, pp 456-462.

[34] Ye, G., Liu, X., De Schutter, G., Poppe, A.M., and Taerwe, L. "Influence of Limestone Powder used as filler in SCC on Hydration and Microstructure of Cement Pastes". *Cement and Concrete Composites*, 29, 2007, pp. 94-102.