International Journal of Advanced Research in Engineering and Technology (IJARET)
Volume 10, Issue 4, July-August 2019, pp. 86-93, Article ID: IJARET_10_04_010
Available online at http://iaeme.com/Home/issue/IJARET?Volume=10&Issue=4
ISSN Print: 0976-6480 and ISSN Online: 0976-6499

CHARACTERISITC STUDY OF NANOSILICA IN DURABILITY ON VARYING WATER-CEMENT RATIO

Ranjith Kumar L
Research Scholar, Department of Civil Engineering,
Sathyabama Institute of Science and Technology, Chennai, Tamilnadu, India.

Dr. Mageswari. M
Professor, Department of Civil Engineering,
Panimalar Engineering College, Chennai, Tamilnadu, India.

ABSTRACT

The purpose of this work is to describe the effect of durability aspect of Nano silica when added to concrete. The use of Nanosilica in concrete is to reduce the cement content in concrete mix since the design consumes almost the total cement production in the world. Nanotechnology is one of the most active research areas which has wide applications in almost all the fields. Researchers are focusing to improve the durability and sustainability of concrete by incorporating Nanosilica. This paper summarizes the effect of Nanosilica addition on compressive strength, chloride penetration test, electrical resistivity and carbonation resistance test in varying water-cement ratio of 0.65, 0.55 and 0.5 and NS in 0%, 0.5%, 1% and 1.5% by weight.

The effect of certain NS dosage on compressive strength and durability properties for high strength concrete mix was different than low strength mixes.

Keywords: Nanosilica, durability, water-cement ratio, strength

Cite this Article: Ranjith Kumar L and Dr. Mageswari M, Characterisitc Study of Nanosilica in Durability on Varying Water-Cement Ratio. *International Journal of Advanced Research in Engineering and Technology*, 10(4), 2019, pp. 86-93.

http://iaeme.com/Home/issue/IJARET?Volume=10&Issue=4

1. INTRODUCTION

Nanotechnology is one of the most active research areas which have wide applications in almost all the fields. As concrete is most usable material in construction industry it's been required to improve its quality. Improving concrete properties by addition of Nano particles have shown significant improvement than conventional concrete. It improves the material bulk properties. Nano is used to obtain thinner final products and faster setting time. It is cost effectiveness and it has lowered levels of environmental contamination. A concrete made with Portland cement particles that are less than 500nm as a cementing agent is called Nano concrete. Currently cement particle sizes range from a few Nano-meters to a maximum of about 100 micro meters.

The production method of Nano silica is based on a gel process at room temperature. In this process the materials Na_2Sio_4 are added to a solvent and the pH of the solution is changed, reaching the precipitation of silica gel. The produced gel is aged and filtered. Nano materials are defined as a set of substances where at least one dimension is less than approximately 100 nanometres. Some of main Nano materials used in concrete are Carbon Nanotubes, Nanosilica and Polycarboxylates. Properties of Nanosilica includes high compressive strengths, high workability with reduced water-cement ratio, use of super plasticizing additives is unnecessary, fill up all the micro pores and micro spaces and cement saving is up to 35-45%.

2. PROPERTIES OF NANOSILICA

Table 1 Properties of Nanosilca

Physical Properties	Chemical Properties
Colour – White	pH – 4.12
SG – 1.12	SiO_2 – 99.1%
Particle size – 17nm (TEM)	Carbon – 6%
Solid Content – 39%	Chloride – 6%
Tamped density – 44g/L	Al_2O_3 – 0.5%
Loss on dry at 10S°C – 0.47	TiO_2 – 0.4%
Loss on ignition at 1000°C – 0.66	Fe_2O_3 – 0.1%
Specific surface area – 202 m^2/g	

3. MATERIAL TESTING RESULTS

Table 2 Material Testing Results

Properties	Result
Specific Gravity of Fine Aggregate	2.66
Fineness modulus of fine aggregate	4.14%
Specific Gravity of Coarse Aggregate	2.68
Fineness modulus of Coarse aggregate	7.13%
Consistency	Time for remolding is 15 Sec – Concrete is very stiff
Flow Value	6%

4. SLUMP VALUES

Table 3 Slump Test Results

W/C	NS (%)	Cement	NS	Composition kg/m³			SP	Slump (mm)
				Water	FA	CA		
0.65	0	308	-	200	924	924	1.5	175
	0.5	306.5	1.5				1.5	120
	1	304.9	3.1				1.5	75
	1.5	303.4	4.6				1.5	30

W/C	NS (%)	Cement	NS	Composition kg/m^3			SP	Slump (mm)
				Water	FA	CA		
0.55	0	344	-	189	924	924	2.4	240
	0.5	342.3	1.7				2.4	105
	1	340.6	3.4				2.4	40
	1.5	338.8	5.2				2.4	40
0.5	0	366	-	183	922	922	1.8	50
	0.5	364.2	1.8				2.6	80
	1	362.3	3.7				3.1	150
	1.5	360.5	5.5				5.5	60

Addition of 1.5% NS decrease the slump from 175 to 240 mm as a reference slump of concrete with w/c = 0.65 and 0.55 to 30 and 40 mm. This could be by the formation of structure that has high water retention after the addition of NS. The amount of lubricating water in the mixture was reduced; thus, viscosity of fresh concrete may increase and slump may decrease. The slump value for w/c = 0.5 did not decrease with respect to increasing dosage of NS, since higher amount of SP was used for better workability during casting.

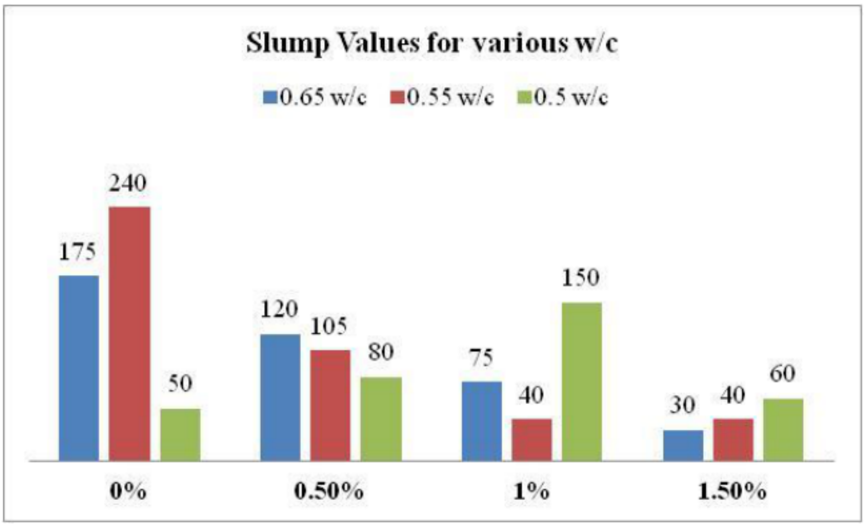

Figure 1 Slump Test Values on Varying w/c and Nano silica percentage

5. SAMPLE PREPARATION AND METHODS

Concrete samples with w/c ratios of 0.65, 0.55 and 0.5 were cast. For each w/c ratios three NS contents of 0.5, 1, and 1.5% with respect to cement mass were considered. For each type of concrete 4 cubes of 150x150x500mm were cast for compressive strength. A slab with 500x395x60 mm dimension was also cast. Cylindrical samples with nominal diameter 100 mm diameters were cored from the slab at the age of 28 days of curing. The surface in contact with mould was ground, while the casting surface remained unchanged.

5.1. COMPRESSIVE STRENGTH

The compressive strength test was performed on cubes moist in curing chamber for 7 and 28 days.

5.2. CHLORIDE PENETRATION TEST

The specimens were placed in vacuum container with absolute pressure for 3h. The container was filled with demineralized water for 1h. Soon after, the samples were placed in the lab for 2–4 h in order for their surface to become dry. All the surfaces but one (mould surface) were covered with epoxy resin and immersed in saturated calcium hydroxide for 18h and were finally immersed in sodium chloride solution. Chloride content (%) of each layer was obtained and apparent chloride diffusion coefficient D_{app} and surface chloride content CS were obtained through the interpolation.

5.3. ELECTRICAL RESISTIVITY

The electrical resistivity test was done by measuring conductance, G, across cylindrical specimens. The mould surface of the samples was not ground for this test. The samples were immersed in water and kept at 20–25∘C temperature; the conductance was recorded. The conductance was then converted to electrical resistivity, ρ, in Ωm

Electrical resistivity $\rho = \frac{A}{(l \times G)}$

Where, A = surface area; l = height of samples

5.4. CARBONATION RESISTANCE

Cylindrical specimens were conditioned inside the lab for 14 days with 18–25°C temperature and 50–65% relative humidity and the side surface of the specimens was then covered with epoxy resin. The depth of carbonation was measured (by 0.5mm accuracy) after 45 and 135 days by phenolphthalein indicator. The data was interpolated with and carbonation coefficient K (mm/√year) was determined:

$X = K \sqrt{t}$

6. RESULT AND DISCUSSIONS

6.1. COMPRESSIVE STRENGTH RESULTS

The 28 days compressive strength with w/c = 0.65 improved considerably by NS addition from control value of 34.3 to 43.4 MPa for 1.5% NS addition. The 7 days strength increase from 30 to 35.6 MPa. For w/c = 0.55, the 28-day strength was elevated moderately from control mix 47.5 to 56.3 MPa with 1% NS addition. The 7 days strength increase from 42.2 to 47.5 MPa. No change was observed in the 28-day strength when w/c = 0.5, while 7 days strength raised from 47.5 to 50.6 MPa with 1.5 NS

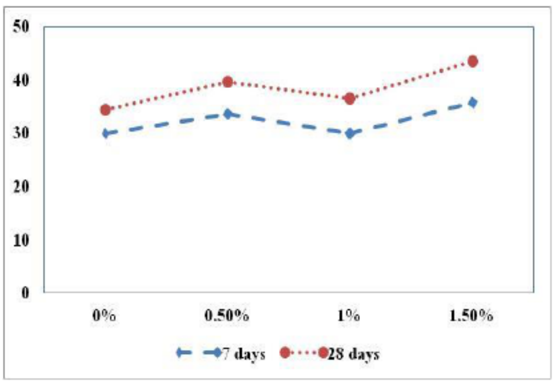

Figure 1 – Compressive Strength for w/c = 0.65

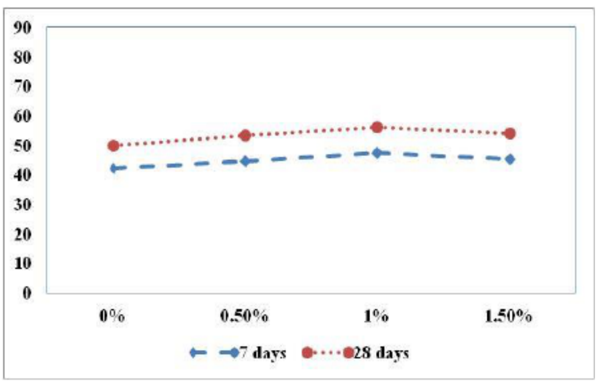

Figure 2 – Compressive Strength for w/c = 0.55

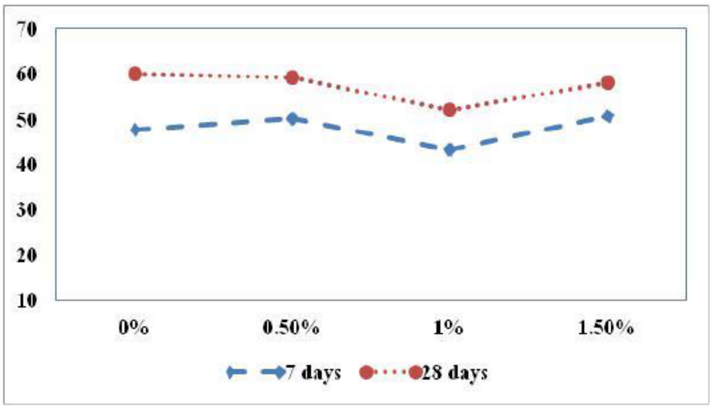

Figure 3 – Compressive Strength for w/c = 0.5

6.2. CHLORIDE PENETRATION RESISTANCE

The apparent chloride diffusion coefficient, D_{app} and surface chloride content C_s of each concrete were calculated and presented in figures. For w/c = 0.65, the D_{app} decreased from reference value 19.1 to 16.2 x10^{-12} m^2/s for 0.5% NS and increased to 32 x10^{-12} m^2/s for 1% NS; then it decreased to 20.9x10-12 m^2/s for 1.5% NS, close to reference value. For w/c = 0.55, the D_{app} decreased from reference value 18.2 to 12 x10^{-12} m^2/s for 0.5% NS and increased with addition of higher dosage.

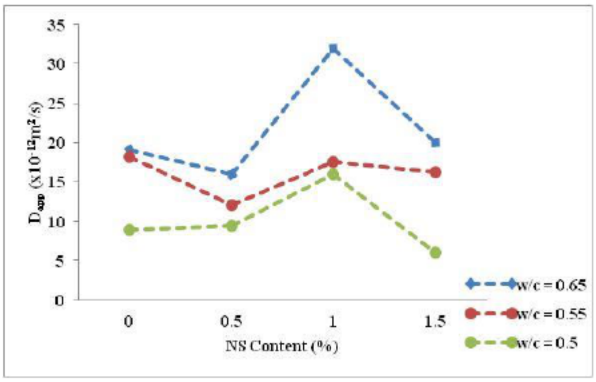

Figure 4 – D_{app} for w/c = 0.65

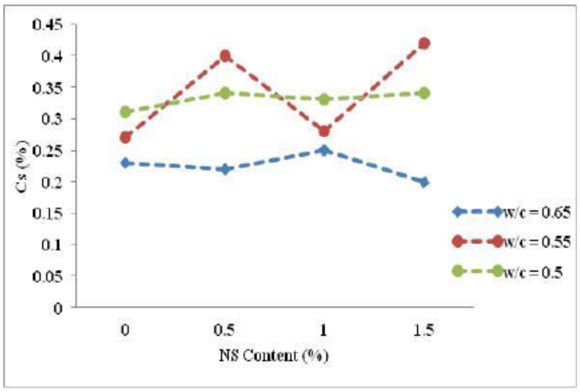

Figure 5 – D_{app} for w/c = 0.55

6.3. ELECTRICAL RESISITIVITY RESULTS

The average electrical resistivity after immersion with water and the resistivity after drop is labelled as ρi then resistivity increased and the average value after 85 days is ρ85. An addition of 0.5% of NS led ρi to increase with respect to reference from 52 to 59 Ωm, 55 to 63 Ωm and 68 to 76 Ωm for w/c = 0.65, 0.55 and 0.5 respectively. The highest reading of ρi was 90 Ωm for 1.5% NS with w/c = 0.5. The ρ85 is close to ultimate and showed approximately similar trend with that of ρi by increasing NS content.

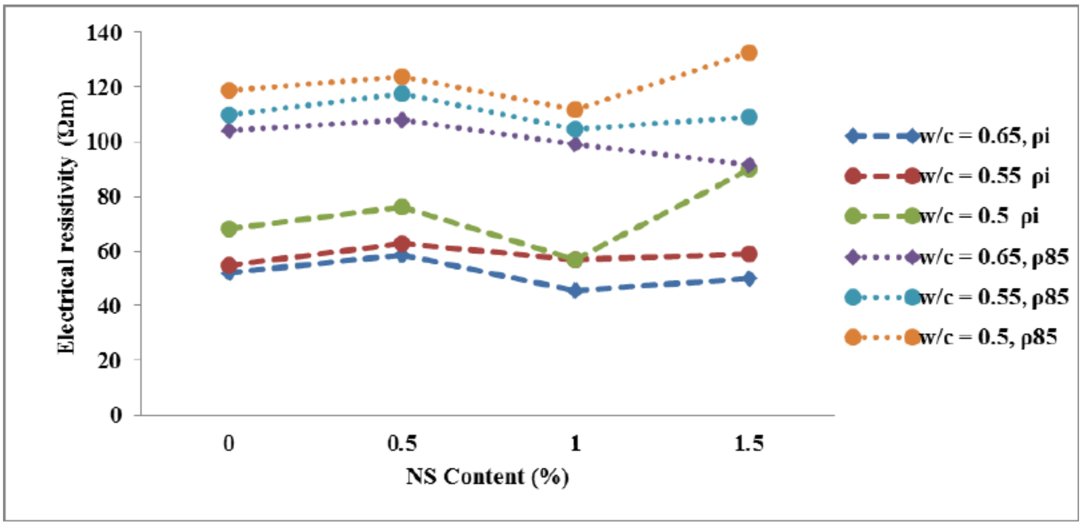

Figure 6 – Electrical Resistivity result for w/c = 0.65, 0.55 and 0.5

6.4. CARBONATION RESISTANCE

For w/c = 0.65, K increased from control of 16 to a maximum of 24 mm/√year for 1% NS addition. For w/c = 0.55, K was reduced from 15 to a minimum of 12 mm/√year for 1% NS. For w/c = 0.5, no significant changes for K values were observed. A typical curve of carbonation depth versus time of exposure is presented.

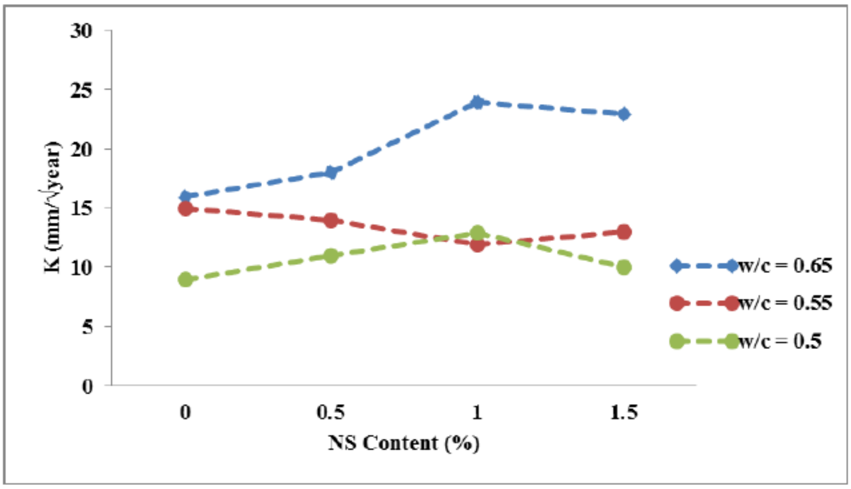

Figure 7 – Carbonation resistance test result for w/c = 0.65, 0.55 and 0.5

6.5. RELATIVE VALUE DETERMINATION

The Relative value is defined as the ratio between the samples containing NS and that of the corresponding control with similar w/c ratio and curing time, multiplied by 100. A value above 100% shows an increase in the property, while below 100% shows a decrease.

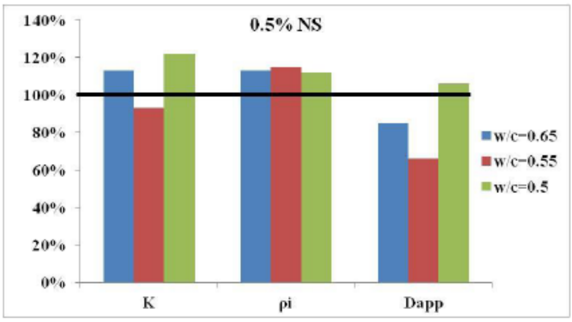

Figure 8 – Relative value for 0.5% NS

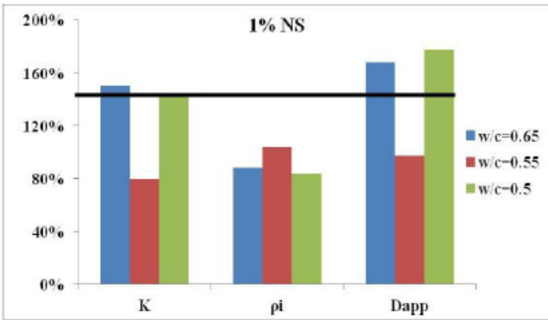

Figure 9 – Relative value for 1% NS

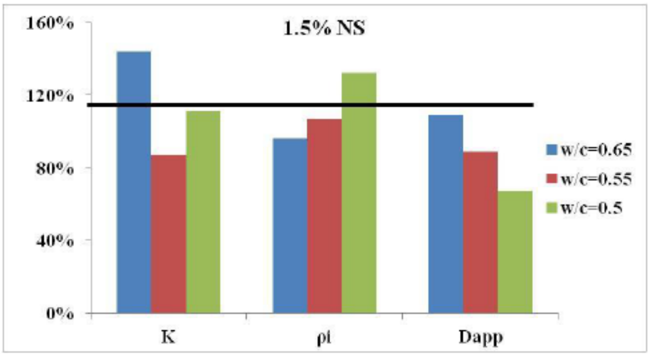

Figure 10 – Relative value for 1.5% NS

7. CONCLUSIONS

- Effect of certain NS dosage on compressive strength and durability properties for high strength concrete mix was different than low strength mixes
- By the incorporation of 1.5% NS into concrete with w/c = 0.65, 0.55 and 0.5, strength gains 41%, 6.5% and nil respectively
- Durability properties of concrete with different w/c ratios shows highly varying tendency by increasing NS dosage.
- Apparent chloride diffusion coefficient of concrete decreased with 0.5% NS addition for w/c = 0.65 and 0.55 however it did not decrease with the addition of higher NS as 0.5%
- The electrical resistivity of saturated specimen increased after the addition of 0.5% NS for all w/c ratio. For w/c = 0.5, it also increased for 1.5% NS addition
- NS addition for w/c = 0.65 the carbonation coefficient was elevated from the reference of 16 to 23 mm/□year by 1% NS

REFERENCES

[1] Aswini Devi A.S (2016), "Experimental Investigation of durability characterisitcs of concrete by adding Nano Silica, Glass fibre and partial replacement of cement by Flyash" International Journal of Engineering Research & Technology (IJERT), Volume 4, Issue 08, pp. 1-4, ISSN – 2278-0181.

[2] Belkowitz, J. and Armentrout, D. L. (2009). The Investigation of Nano Silica in the Cement Hydration Process. ACI Special Publication 267(8): 87-100.

[3] G. Yamini and Dr. S. Siddiraju (2016), An Experimental Research on Strength Propereties of Concrete by The Influence of Flyash and Nanosilica as A Partial Replacement of

Cement. International Journal of Civil Engineering and Technology, 7(3), 2016, pp.306–315.

[4] Surenra P. Shah, et al. (2010). "Controlling Properties of Concrete through Nano Technology" (ACBM Centre, North Western University, USA), Proc. of the International Conference on advances in Concrete, ICI-ACECON 2010, 5-9 Dec., IIT, Madras, India, PP 1-8.

[5] G Reddy Babu., (2013). "Effect of Nano-Silica on properties of Blended Cement" Vol 03 Issue, 5 pp. 50 – 55.

[6] R. Roselin and Dr. M.S. Ravikumar (2018), Experimental Investigation on Concrete Using Nanosilica as Mineral Admixture, International Journal of Civil Engineering and Technology, 9(6), 2018, pp. 1464–1469.

[7] Rushabh A. Shah and Jayeshkumar R. Pitroda, "Assessment of Sorptivity and Water Absorption of Mortar with Partial Replacement of Cement by Fly Ash (CLASSF)", International Journal of Civil Engineering & Technology (IJCIET), Volume 4, Issue 5, 2013, pp. 15 - 21, ISSN Print: 0976 – 6308, ISSN Online: 0976 – 6316.

[8] Alireza Naji Givi, Surya Abdul Rashid, Influence of 15 and 80 nano-SiO2 particles addition on mechanical and physical properties of ternary blended concrete incorporating rice husk ash. Composites (part B) Vol-42-s (2011) 562-569

[9] Rathi V. R, C.D. Modhera, Experimental study on effect of Colloidal Nano SiO2 and Fly Ash addition on properties of cement mortar, International Journal of Advanced Structures and Geotechnical Engineering ISSN 2319-5347, Vol. 03, No. 03

[10] Min-Hong Zhang and Jahidul Islam (2011) Use of Nano-silica to reduce Setting Time and Increase Early Strength of Concretes with High Volumes of Flyash or Slag, Construction and Building materials, 29, 573- 580

[11] Nura Bala, Madzlan Napiah and Ibrahim Kamaruddin (2017), Performance Evaluation of Composite Asphalt Mixture Modified with Polyethylene and Nanosilica, International Journal of Civil Engineering and Technology, 8(9), 2017, pp. 616–628.

[12] Kavitha S, Sandhiyadevi A (2015), "Experimental evaluation of the influence of Nanosilica on properties of concrete" Internation Journal of Innovative Science, Engineering & Technology, Vol 3, Issue 6, ISSN (Online) 2348-7968, pp 644 – 648

[13] Sivakumar K, Jose Ravindra Raj B (2016), "Durability investigation on Nanosilica and Nano cement-based concrete" International Journal of Engineering and Management Research (IJEMR) Volume 6 Issue 2, ISSN (Online) 2250-0758, pp 314 – 315

[14] OSENI O. W. and AUDU T.M. (2016), The Effects of Percentage Compositon of Millet Stem Ash (MSA) and Water Cement Ratio on The Properties Composite Concrete, International Journal of Civil Engineering and Technology, 7(1), 2016, pp. 427-440.

[15] S.Gopinath, P.C.H. Mouli, A.R.Murthy, N.R.Iyer, S.Maheswaran, Effect of Nano silica on mechanical properties and durability of normal strength of concrete, Archives of Civil Engineering, LVIII,4, 2012.