International Journal of Research in Advent Technology, Vol.7, No.4, April 2019
E-ISSN: 2321-9637
Available online at www.ijrat.org

The Electrical Resistivity Of Nano – Al_2o_3 Particles Blended Ultra High Performance Concrete

S. Karnal Preeth[1] and K. Mahendran[2]
Research Scholar[1]and Professor[2], Centre for Rural Technology, The Gandhigram Rural Institute-Deemed to be University, Gandhigram-Dindigul. karnalpreeth@gmail.com[1] and mahendran_gri@rediffmail.com[2]

Abstract- In the present investigation, the electrical resistivity of ultra high performance concrete (UHPC) containing nano Al_2O_3 particles have been investigated at an age of 28th, 56th and 90th days. The cement was partially replaced by 0.5%, 1%, 1.5%, 2% and 3% nano Al_2O_3. The results were revealed that increasing the nano Al_2O_3 particles have found to be reducing the current passing on the concrete surface and improves the electrical resistivity of ultra high performance concrete, this may be due to better packing of nano Al_2O_3 was reduced the porosity.

Key words - Nano Al_2O_3; Ultra High Performance Concrete; Electrical Resistivity.

1. INTRODUCTION

The last two decade ultra high performance concrete is becoming the most promising type of concrete and having a superior mechanical and durability performance [1]. The utilization of nanomaterials in UHPC is highly effective SCM for cement matrix [2]–[4]. This is due to very small size, nanoparticles will fill the pores in the cement matrix, that leads to improving packing density and microstructural properties. In recent days, many researchers focusing utilization of nano Al_2O_3 particles in cement paste, mortar and concrete [5]–[10]. Still now, only a few studies were available on the utilization of nano Al_2O_3 in ultra high performance concrete. The literature of previous works on nanomaterial and UHPC showed that, there is a lack in the studies of electrical resistance behavior of nano Al_2O_3 particles replaced ultra high performance concretes. The present investigation aims to study the effects of Al_2O_3 particles replacement on electrical resistivity properties of UHPC at the age of 28, 56 and 90 days.

2. LITERATURE REVIES:

Li et al [11] studied the effects of nano Al_2O_3 and graphene oxide replacement on a heat of hydration in cement, compressive strength, flexural strength and electrical resistivity of cement paste. The cement paste was produced with constant w/b of 0.36 and cement was replaced by weight of 0%, 2%, 4% and 6% nano Al_2O_3 particles having a size of 13 nm and specific surface area of greater than $40m^2/g$. The optimum percentage of replacement was 2%, gives the better results comparatively from all other mix proportion. The results revealed that nano Al_2O_3 particles addition was accelerated the hydration process, improves the compressive and flexural strength and enhance the electrical resistivity properties of cement paste.

Stefanc et al [12] studied the effects of nano α-Al_2O_3 replacement on Centrifugal consolidation test, isothermal calorimetry, compressive strength and mercury intrusion porosimetry (MIP) studies in the cement paste. The cement paste was produced with constant w/b of 0.24 and polycarboxylate ether dosage 1% of all mix proportions and cement was replaced by weight of 0 %, 2 %, 4 %, 6 %, 8 % and 10 % nano α-Al_2O_3 particles having size of 500 nm and specific surface area of $9.22m^2/g$. The optimum percentage of replacement α-Al_2O_3 particles was 2%, gives the better results comparatively from all other mix proportion. The result revealed that nano α-Al_2O_3 particle addition was accelerating the hydration process, improves the compressive and flexural strength and enhance the electrical resistivity properties of cement paste.

Gowda et al [13] studied the effects of nano Al_2O_3 particles replacement on water absorption, electrical resistivity and SEM studies in mortar. The mortar was produced with constant w/b of 0.79 and cement was replaced by weight of 0 %, 1 %, 3 %, and 5 % nano Al_2O_3. The optimum percentage for replacement of Al_2O_3 particles was 5 %, gives the better results comparatively from all other mix proportion. The result revealed that nano Al_2O_3 particle addition was improved the durability and microstructure of mortar.

Miyandehi et al [14] studied the effects of nano Al_2O_3 particles replacement on Slump, V-funnel flow, Compressive Strength, Flexural strength, Water absorption, Electrical resistivity and rapid chloride permeability studies in mortar. The mortar was produced with constant w/b of 0.40, Fly Ash was replaced 25% of cement weight for all proportions and cement was replaced by weight of 0 %, 1%, 3% and 5% of nano Al_2O_3 particles having size of 15nm and SSA of 200 m^2/g. The optimum percentage for replacement of nano Al_2O_3 particles was 1%, gives the better results comparatively from all other mix proportion. The result revealed that nano Al_2O_3 particle addition was improves the workability, mechanical and durability Properties of the mortar.

Mohseni et al [15] studied the effects of unitary ,binary and ternary blends of nano Al_2O_3, nano SiO_2 and nano TiO_2 particles replacement on Slump, V-funnel flow, Compressive Strength, Flexural strength, Water absorption, Electrical resistivity and RCPT studies in mortar. The mortar was produced with constant w/b of 0.40, superplasticizer dosage was 0.64%, Fly Ash was replaced 25% of cement weight for all proportions, and cement was replaced by weight of 0 %, 1%, 3% and 5% of Al_2O_3, nano SiO_2 and nano TiO_2 particles. The optimum percentage for replacement of nano Al_2O_3, nano SiO_2 and nano TiO_2 particles was ternary blends (1% nano Al_2O_3, 1% nano SiO_2 and 1% nano TiO_2) was gives the better results comparatively from all other mix proportion of unitary, binary and ternary blends nano Al_2O_3, nano SiO_2 and nano TiO_2 particles. Unitary blend of nano Al_2O_3 particles was improves the compressive strength and durability properties of mortar comparatively from control mix. However a combined effect binary and ternary blends of Nano Al_2O_3, Nano SiO_2 and Nano TiO_2 gives the better performance on mortar comparatively all other Mix. The result revealed that nano Al_2O_3 particle addition was improves the workability, mechanical and durability Properties of the mortar.

Mohseni and Tsavdaridis 2016 [16] had studied the effects of colloidal nano Al_2O_3 particles replacement on Slump, V-funnel flow, Compressive Strength, Flexural strength, Water absorption, SEM, MIP, Electrical resistivity and RCPT of analysis in mortar. The mortar was produced with constant w/b of 0.40, Fly Ash was replaced 25% of cement weight for all proportions and cement was replaced by weight of 0 %, 1%, 3% and 5% of colloidal nano Al_2O_3 particles having size of 15nm and SSA of 200 m^2/g. The optimum percentage for replacement of colloidal nano Al_2O_3 particles was 1%, gives the better results comparatively from all other mix proportion. The result revealed that colloidal nano Al_2O_3 particle addition was improves the workability, mechanical and durability Properties of the mortar.

3. MATERIALS AND METHODS

The OPC-53 grade cement [17], silica fume [18], Quartz powder, nano Al_2O_3 (size 20-30nm and surface area of 180 m^2/g), River sand, Polypropylene fibers [19], Polycarboxylic ether super-plasticizer [20] were used for fabrication of UHPC. The six different mixture proportions, was developed based ASTM C1856/C1856M-17 guideline [21]. The CON mixture was without nano Al_2O_3 particles and other five mixture proportions were containing 0.5%, 1%, 1.5%, 2% and 3% nano Al_2O_3 replaced by weight of cement. Tables 1**,** show the mixture proportions details of six series mix. The six series of mixes mixed with mortar mixture machine [22]. Then fresh Concrete placed into the 40 x 40 x 160 mm prisms and 100mm diameter and 200 mm height cylinders. After 24 hours, the demoulded specimens were placed in water curing for 28 days [23].

Table 1 Mix proportions by cement weight

Mix ID	Cement	Silica Fume	Nano Al_2O_3	Sand	Quartz Powder	w/b Ratio	PCE	Fiber	Compressive Strength (28^{th} day)
CON	1	0.30	0	2.183	0.430	0.24	0.04	0.004	122.65
0.5AL	0.995	0.30	0.005	2.183	0.430	0.24	0.04	0.004	130.18
1.0 AL	0.99	0.30	0.01	2.183	0.430	0.24	0.04	0.004	136.8
1.5 AL	0.985	0.30	0.015	2.183	0.430	0.24	0.04	0.004	147.02
2.0 AL	0.98	0.30	0.02	2.183	0.430	0.24	0.04	0.004	155.59
3.0 AL	0.97	0.30	0.03	2.183	0.430	0.24	0.04	0.004	145.40

4. EXPERIMENTAL TECHNIQUES:

The surface electrical resistivity of UHPC was measured at age 28^{th} day, 56^{th} day and 90^{th} days of curing according to the Wenner Four Probe Electrical Resistivity method and the electrical resistivity calculated by **Equation (1)**. Figure 1 shows the electrical resistivity test setup.

$$\text{Electrical resistivity } (\boldsymbol{\rho}) = 2\,\pi\,\text{a R} \quad \text{Equation (1)}$$

Where,

ρ -Resistivity (KΩ.cm)
a - Spacing between pin {depth of electrode shall not exceed the value of $a/20$} (cm)
R - Resistance measurement in (Ω)

Figure 1 Electrical Resistivity Setup

5. RESULTS & DISCUSSIONS:

The electrical resistivity of UHPC mixes was tested according to the Wenner Four Probe Electrical Resistivity method. The effect of nano Al_2O_3 particle replacement on the electrical resistance properties of UHPC specimens was shown in Figure 2,and tested at the age of 28^{th} day, 56^{th} day and 90^{th} day of curing. The low electrical resistivity performance observed in CON mix was 212KΩ.cm, 245KΩ.cm and 289KΩ.cm, respectively at age of 28^{th} day, 56^{th} day and 90^{th} days comparatively from other mix proportions. The high electrical resistivity performance observed in 2.0 AL mix was 350KΩ.cm, 364KΩ.cm and 388KΩ.cm, respectively at age of 28^{th} day, 56^{th} day and 90^{th} day comparatively from other mix proportions. Because of filler effect nano Al_2O_3 particles in cement matrix, leads to resistance against the passing an electrical current in UHPC.

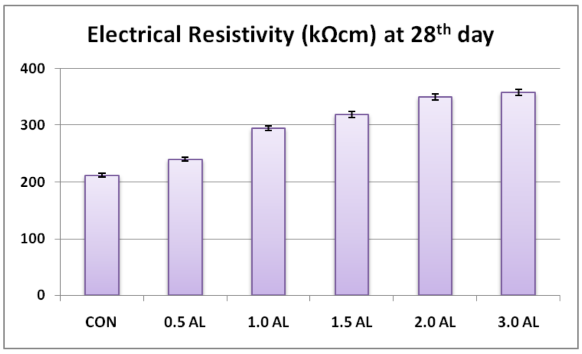

Figure 2 the electrical resistivity

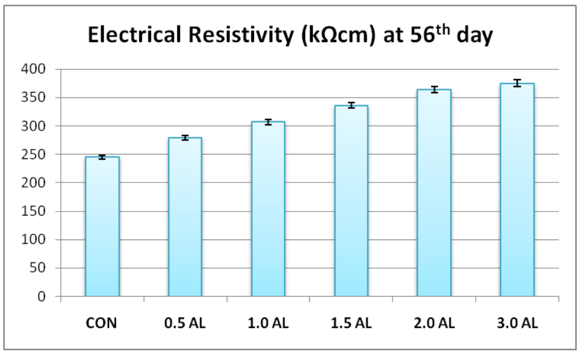

Figure 3 the electrical resistivity

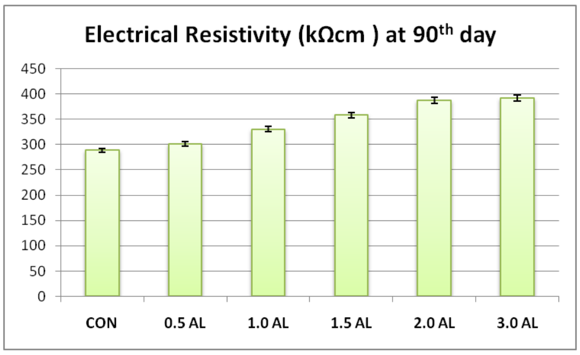

Figure 4 the electrical resistivity

6. CONCLUSIONS:

The enhancement of electrical resistivity of the specimens was increasing with the nano particles content and age of curing. The well optimized UHPC mixture containing nano Al_2O_3 particle was improves the better packing, reduces the porosity and making the cement matrix into the homogenous matrix UHPC. According to the result of the experiment, the inclusion of nano Al_2O_3 particles in ultra high performance concrete cement matrix was act as the pore-filling material, increased surface hardness and increases the electrical resistivity. This may be due to the better packing of nano Al_2O_3 has reduced the porosity and improves microstructural properties of concrete.

REFERENCES:

[1] M. G. Sohail *et al.*, "Advancements in Concrete Mix Designs: High-Performance and Ultrahigh-Performance Concretes from 1970 to 2016," *J. Mater. Civ. Eng.*, vol. 30, no. 3, p. 4017310, 2018.

[2] Y. Reches, K. Thomson, M. Helbing, D. S. Kosson, and F. Sanchez, "Agglomeration and reactivity of nanoparticles of SiO_2, TiO_2, Al_2O_3, Fe_2O_3, and clays in cement pastes and effects on compressive strength at ambient and elevated temperatures," *Constr. Build. Mater.*, vol. 167, pp. 860–873, 2018.

[3] R. Roychand, S. De Silva, S. Setunge, and D. Law, "A quantitative study on the effect of nano SiO_2, nano $Al_2O_3$and nano $CaCO_3$ on the physicochemical properties of very high volume fly ash cement composite," *Eur. J. Environ. Civ. Eng.*, vol. 8189, no. December, pp. 1–16, 2017.

[4] J. V Silva *et al.*, "Influence of nano-SiO_2 and nano-Al_2O_3 additions on the shear strength and the bending moment capacity of RC beams," *Constr. Build. Mater.*, vol. 123, pp. 35–46, 2016.

[5] Z. Li, H. Wang, S. He, Y. Lu, and M. Wang, "Investigations on the preparation and mechanical properties of the nano-alumina reinforced cement composite," *Mater. Lett.*, vol. 60, no. 3, pp. 356–359, 2006.

[6] A. Nazari, S. Riahi, S. Riahi, S. F. Shamekhi, and K. A. A., "Mechanical properties of cement mortar with Al_2O_3 nanoparticles," *J. Am. Sci.*, vol. 6, no. 4, pp. 94–97, 2010.

[7] A. Nazari and S. Riahi, "Improvement compressive strength of concrete in different curing media by Al_2O_3nanoparticles," *Mater. Sci. Eng. A*, vol. 528, no. 3, pp. 1183–1191, 2011.

[8] N. León, J. Massana, F. Alonso, A. Moragues, and E. Sánchez-Espinosa, "Effect of nano-Si2O and nano-Al_2O_3on cement mortars for use in agriculture and livestock production," *Biosyst. Eng.*, vol. 123, pp. 1–2, 2014.

[9] J. Liu, Q. Li, and S. Xu, "Influence of nanoparticles on fluidity and mechanical properties of cement mortar," *Constr. Build. Mater.*, vol. 101, pp. 892–901, 2015.

[10] S. Mahmoud Sheikhaleslamzadeh and M. Raofi, "The Effect of Nano-Al_2O_3 on the Fiber-reinforced Concrete," *Res. J. Appl. Sci. Eng. Technol.*, vol. 13, no. 10, pp. 784–786, 2016.

[11] W. Li, X. Li, S. J. Chen, G. Long, Y. M. Liu, and W. H. Duan, "Effects of Nanoalumina and Graphene Oxide on Early-Age Hydration and Mechanical Properties of Cement Paste," *J. Mater. Civ. Eng.*, vol. 29, no. 9, pp. 1–9, 2017.

[12] M. Stefanc, A. Mladenovic, M. Bellotto, V. Jereb, and L. Završnik, "Particle packing and rheology of cement pastes at different replacement levels of cement by a -Al_2O_3 submicron particles," *Constr. Build. Mater.*, vol. 139, pp. 256–266, 2017.

[13] R. Gowda, H. Narendra, D. Rangappa, and R. Prabhakar, "Effect of nano-alumina on workability, compressive strength and residual strength at elevated temperature of Cement Mortar," *Mater. Today Proc.*, vol. 4, pp. 12152–12156, 2017.

[14] B. M. Miyandehi, B. Behforouz, E. M. Khotbehsara, H. A. Balgouri, S. Fathi, and M. M. Khotbehsara, "An experimental investigation on nano-Al_2O_3 based self-compacting mortar Bahareh," *J. Am. Sci.*, vol. 10, no. 11, pp. 229–233, 2014.

[15] E. Mohseni, B. M. Miyandehi, J. Yang, and M. A. Yazdi, "Single and combined effects of nano-SiO2, nano-$Al_2O_3$and nano-TiO_2on the mechanical, rheological and durability properties of self-compacting mortar containing fly ash," *Constr. Build. Mater.*, vol. 84, pp. 331–340, 2015.

[16] E. Mohseni and K. D. Tsavdaridis, "Effect of Nano-Alumina on Pore Structure and Durability of Class F Fly Ash Self-Compacting Mortar," *Am. J. Eng. Appl. Sci.*, vol. 9, no. 2, pp. 323–333, 2016.

[17] IS-12269, "Ordinary Portland Cement, 53 Grade-Specification," 2013.

[18] IS 15388, "Specification for Silica Fume," 2003.

[19] BS EN 14889-2, "Fibres for concrete- Part 2: Polymer fibres - Definitions, specifications and conformity," 2006.

[20] IS 9103, "Specification for Concrete Admixtures," 1999.

[21] ASTM C1856/C1856M − 17, "Standard Practice for Fabricating and Testing Specimens of Ultra-High Performance Concrete," pp. 1–4, 2018.

[22] IS 1727, "Methods of test for pozzolanic materials," 1967.

[23] ACI 308R.01, "Guide to Curing Concrete," 2008.