EXPERIMENTAL INVESTIGATION OF PHYSICAL, MECHANICAL AND ELECTRICAL PROPERTIES OF CEMENT MORTAR USING NANO FLY-ASH

ABHIJIT MANGARAJ[1]

K.I.I.T. University, Bhubaneswar, Orisha, India

ABSTRACT

Mechanical performances of a variety of materials are being influenced by reducing the surface area, surface chemistry, and surface morphology of the particle this, including metals, polymers, ceramic, and concrete composites. Nano-engineered concrete can be synthesized by incorporating Nano-sized building blocks or objects (e.g., nanoparticles and nanotubes) to control the behaviour of the material and adds novel properties by grafting molecules onto cement particles, and aggregates. Micro/Nano fly-ash for example, has been shown to improve workability and strength in concrete in this paper. Substitute material is named so because its particles possess size in both Nano and micro level which was obtained from particle size analysis data. Further this sample is authenticated by compressive, flexural, water absorption, SEM, XRD and LCR tests. Here the strength properties of cement mortars with Nano-flyash were experimentally studied. The rate of the reaction is proportional to the amount of surface area available for reaction. Therefore, it is plausible to add Nano-flyash particles in order to make high-performance concrete. In this study cement is substituted with Nano fly-ash at (10%, 20%, 30% & 40% by weight) the result from the experiment shows that the compressive strength and flexural strength of mortars with 10% Nano fly-ash particle is highest than those of plain cement mortars and maximum among the blended specimens at 7 and 28 days. Also it was found that water absorbed by specimens cast with Nano fly-ash is less than the normal mortar. It is demonstrated that the Nano incorporated particles are more valuable in enhancing strength. The results of these experiments indicate that Nano scalefly ash behaves not only as a filler to improve microstructure, but also as an element to enhance the compressive strength. It makes the construction process quick and economical.

KEYWORDS: Nano Fly Ash, SEM, XRD

GENERAL

Cement industry produces cement as well as releases different harmful waste into the environment which is harmful for us. The pollution may be reduced by reducing the use of cement to some extent, which indirectly reduces its production. As we know without cement concrete structures are impossible, so cement can be blended with different supplementary cementitious material to form blended cement and can be used instead of cement. Supplementary cementitious materials are those materials which are added in concrete as a part of the total cementitious component reducing the amount of cement to be used. It also helps to increase the strength of the concrete from normal to higher strength. Some of the supplementary cementitious materials such as fly-ash, micro-silica, Nano lime, Nano TiO_2, Nano Fe_2O_3 , Nano $CaCO_3$, Nano Al_2O_3 GGBS (ground granulated blast furnace slag), carbon nanotubes, calcinated shale's and many more are those which are generally blended with cement which contributes to the chemical and physical properties.

In this research paper cement is replaced with Nano sized fly-ash at (10%, 20%, and 40%) by weight respectively, which reduces the voids in concrete ultimately increasing the compressive strength and enhancing different physical properties. Nano sized fly-ash possesses size around 10^{-9} m which makes the concrete or mortar void free. This also decreases the absorption of water in mortar and concrete.

Pozzolans increases the mechanical strength and durability of concrete structure when added to Portland cement. They improve strength by bringing changes in microstructure of the cementitious paste and also in the pore structure by reducing the grain size caused by the pozzolanic reactions and the effect (PE) by reducing the pores and voids by the action of the finer grains [1]. Mineral admixtures such as Micro-silica, Rice hush Ash, Fly ash, bagasse ash [2] which is rich in pozzolanic actions and fillers like lime stone fillers [3] can be used as a partial replacement for cement in high strength concrete. Several works were performed and are still going on regarding the usage of these mineral admixtures in High Strength Concrete (HSC) and High Performance Concrete (HPC).

In the recent years many finer particles are being used in concrete industry. Several works has been performed on use of Nano particles in concrete specimens as mineral admixtures to improve physical and mechanical properties [4]. Most of the works were done using silicon dioxide Nano particles [5-6]. Some of the works were also performed using Nano Al_2O_3 [7], Nano Fe_2O_3 [8] and Zinc-iron oxide Nano particles [9] as mineral admixtures in concrete. Also the use of Nano sized mineral admixtures were also studied on self-

[1]Corresponding author

compacting concrete using SiO_2 [10, 11], Fe_2O_3 [12] and ZnO_2 [13, 14].

In addition the effects of several types of Nano particles on properties of concrete specimens which are cured in different curing media were investigated in several works [14]. From the literatures it is clear that using Nano particle in concrete mechanical properties as well as microstructure of the specimen has been improved. Most of the researchers had done using a small quantity of Nano sized admixtures because of its higher cost of production.

OBJECTIVE OF PRESENT STUDY

The specific objectives of the present study are as below.

1. Study of literature for understanding behaviour of different Nano particles in mortar/concrete.
2. Preparation of Nano fly-ash by using high energy ball milling.
3. Characterization studies of n-FA sample using PSA, XRD
4. Study the influence of compressive strength of various cement mortars with different percentage (10, 20, 30 & 40) by using Nano fly-ash as partial replacement of cement.
5. Study the influence of flexural strength of various cement mortars with different percentage (10, 20, 30 & 40) by using Nano fly-ash as partial replacement of cement.
6. To study the water absorption tests of various n-FA mortar samples having (10, 20, 30 and 40) % of Nano fly-ash as partial replacement with cement.
7. To study the AC Impedance of the sample produced from n-FA cement with respect to normal cement samples by impedance spectroscopy test.

EXPERIMENTAL WORK

Materials Used

Cement

Cement used in the experimental work is ORDIRARY PORTLAND CEMENT of 43 grades conforming to **IS: 8112/2013**

N-Fly Ash

Here fly ash in terms of nano Fly ash is used as filling element in cement mortar as well as to improve the strength properties

Standard Sand

In this project all types of casting of mortar specimens were made using Indian standard sand of three grades of equal quantities.

Water

Clean and portable water free from colour and odour and normal pH value from the college campus was used in this project for casting and curing of samples.

Preparation Of Nano Mortar Specimen

Using standard mix proportion of 1:3 the mortars samples prepared as per IS 2386(part 6):1963 using standard specimen cubes of size 7.06 cm, for compression testing of the specimens. n-FA were added at percentages of (10, 20, 30, 40) And for flexural strength test the specimens according to ASTM standard of size (40 x 40 x 160 mm) were cast. These samples were cured for 3days, 7days and 28 days before test.

RESULTS AND DISCUSSION

Particle Size Analysis Of Nano Fly-Ash

For grinding in high energy ball mill Fly-ash sample was prepared from the sample collected from NALCO plant .At first the sample was sieved properly by using 90 micron sieve to take off the grains and other substances which are mixed in the sample to obtain a more homogeneous sample .then before starting the milling process the sample was placed in hot air oven to make it moisture free for better grinding.

- The results obtained from the particle size analyser are given in table below.

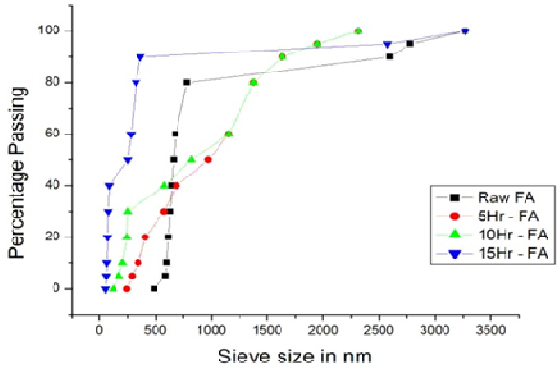

Figure 1: Relationship between % passing at various grind hours.

SEM Of Nano Flyash

The surface morphology and the grain sizes was determined by this and results were determined in the figures given below.

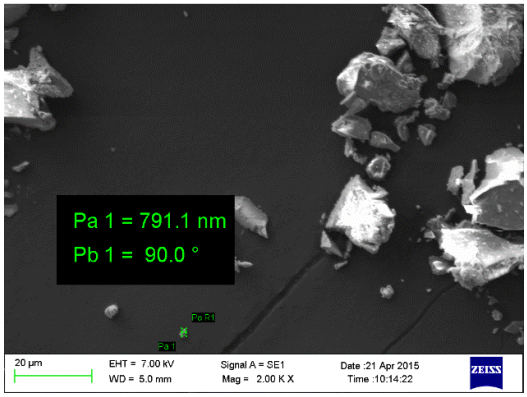

Figure 2: SEM of bulk FA

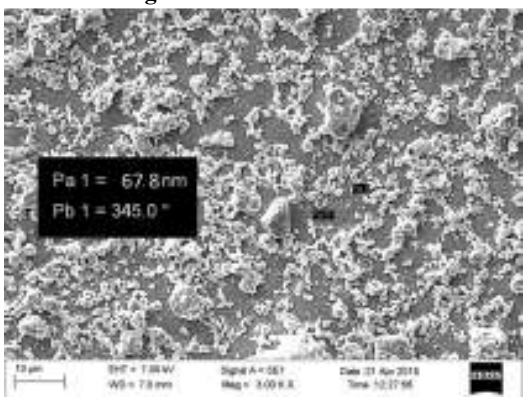

Figure 3: Image of 15Hr grind nano FA sample.

Physical And Rheological Property

Standard Sand according to IS 650:1991(reaffirmed 2008) was used.Consistency and initial/final setting time were determined according to the IS codes , IS 4031(Part 4):1988 respectively.

Table 1: Consistency and setting time of blended cement

Sample name	cement %	n-Fly ash %	Total Amount used for test	consistency %	Setting Time in minutes	
					initial	final
N	100	0	300 gm	30	153	230
N10	90	10	300 gm	31	160	225
N20	80	20	300 gm	32	166	230
N30	70	30	300 gm	32	175	230
N40	60	40	300 gm	33	190	255

Compressive Strength

Strength developed in the mortar samples were determined in the laboratory using compressive strength testing machine and the values were represented below in the following tables.

Table 2: Compressive Strength of cube.

SL NO	Sample Name	Size of Cube in cm	Mean strength in Mpa		
			3D	3D	3D
1	N	7.06	19.795	27.33	34.805
2	N10	7.06	20.785	33.34	**60.245**
3	N20	7.06	21.62	30.79	42.385
4	N30	7.06	19.285	25.95	32.175
5	N40	7.06	17.465	19.735	29.41

Flexural Strength

This test was performed for the determination of strength of the beam/prism specimens in compression and tension directions.

Table 3: Flexural strength of Prism specimens.

Specimen no	Size of prism in mm	MOR in (Mpa)	MOE in (Mpa)	Flexural Strength (N/mm²)
M	160X40X40	0.5	13.19	13.2
M10	160X40X40	0.72	14.28	17.235
M20	160X40X40	0.67	14.16	14.895
M30	160X40X40	0.58	15.84	14.185
M40	160X40X40	0.61	15.58	13.495

Water Absorption

The following table represents the percentage of water absorbed by the samples after curing days.

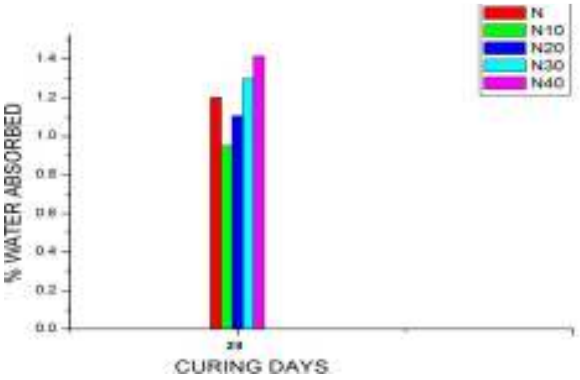

Figure 4: Waterabsorption relation of samples.

Electrical Properties

AC Impedance Study

Electrical impedance is the measure of the opposition that a circuit presents to a current when a voltage is applied. Impedance extends the concept of

resistance to AC circuits, and possesses both magnitude and phase, unlike resistance, which has only magnitude. When a circuit is driven with direct current (DC), there is no distinction between impedance and resistance.

The basis of AC impedance technique is that applying a small alternating voltage on the test material, thus resulting in the corresponding alternating current response, and the impedance of materials in a given frequency can be expressed as:

$$Z(\omega) = E(t) / I(t)$$

This test result shows the passage of amount of electrical charge through the samples of different proportions at different ages.

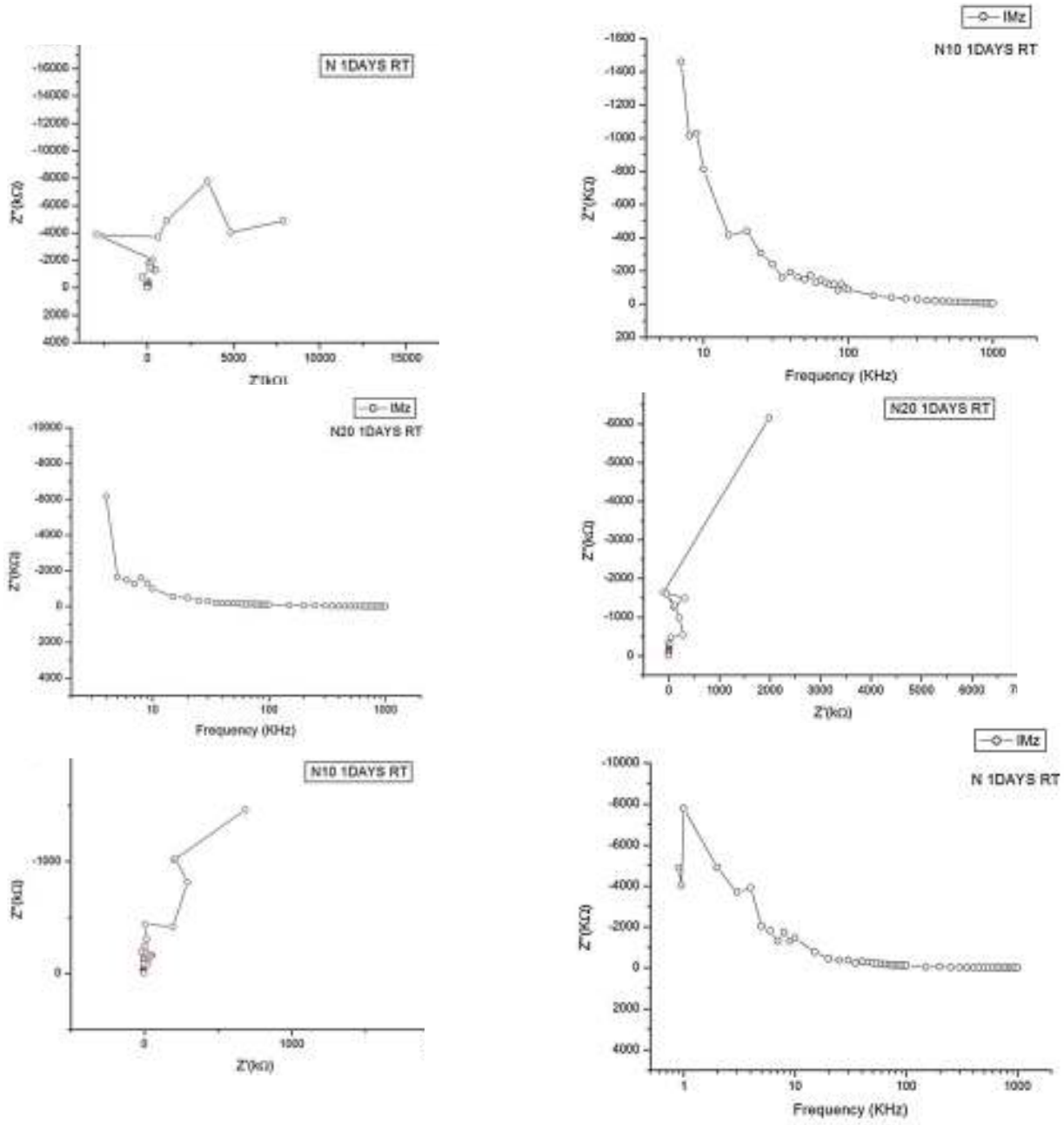

Figure 5: Study of electrical behaviour of blended cement paste samples at 1 day

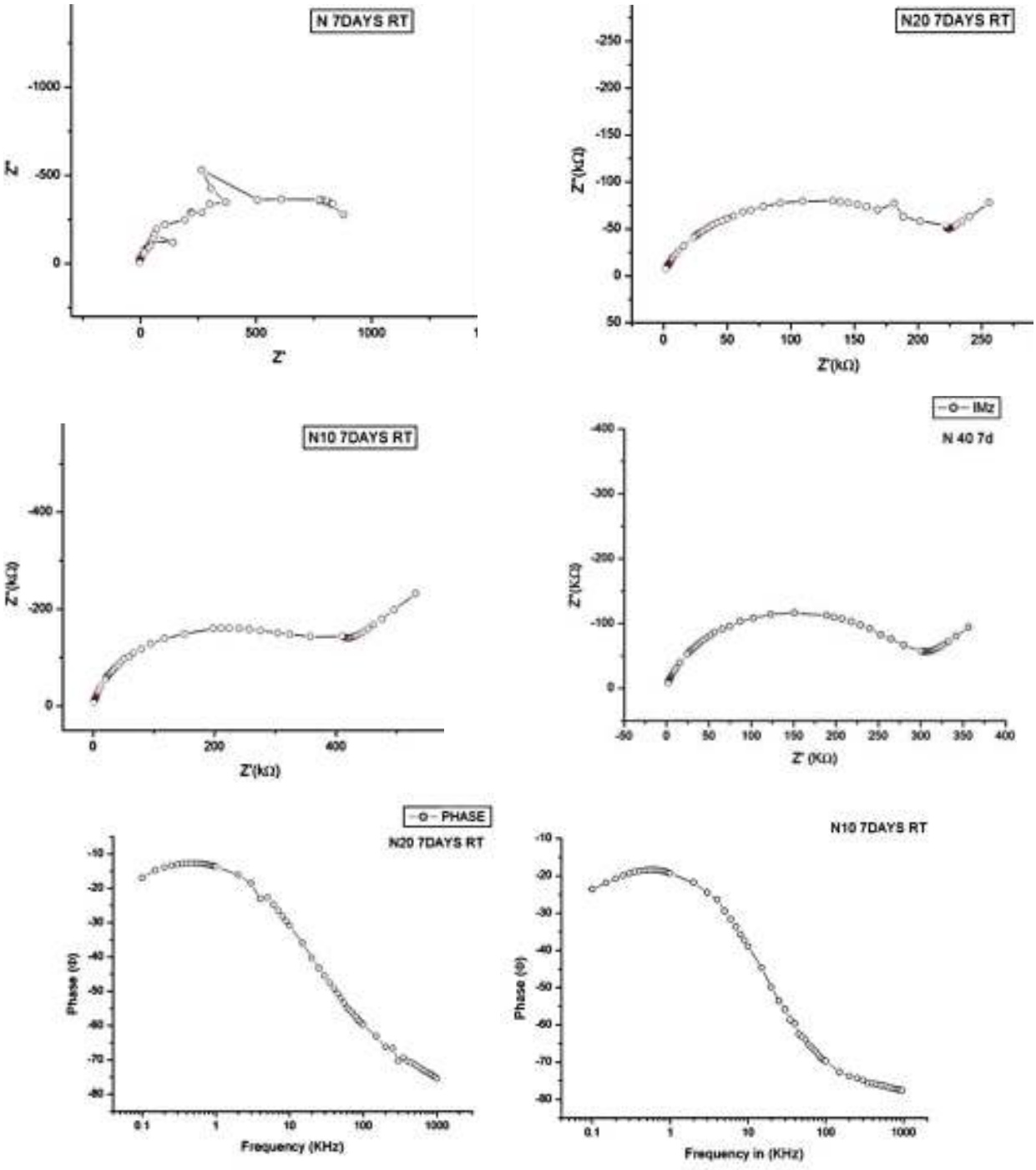

Figure 6: Study of electrical Behaviour of samples at 7 day

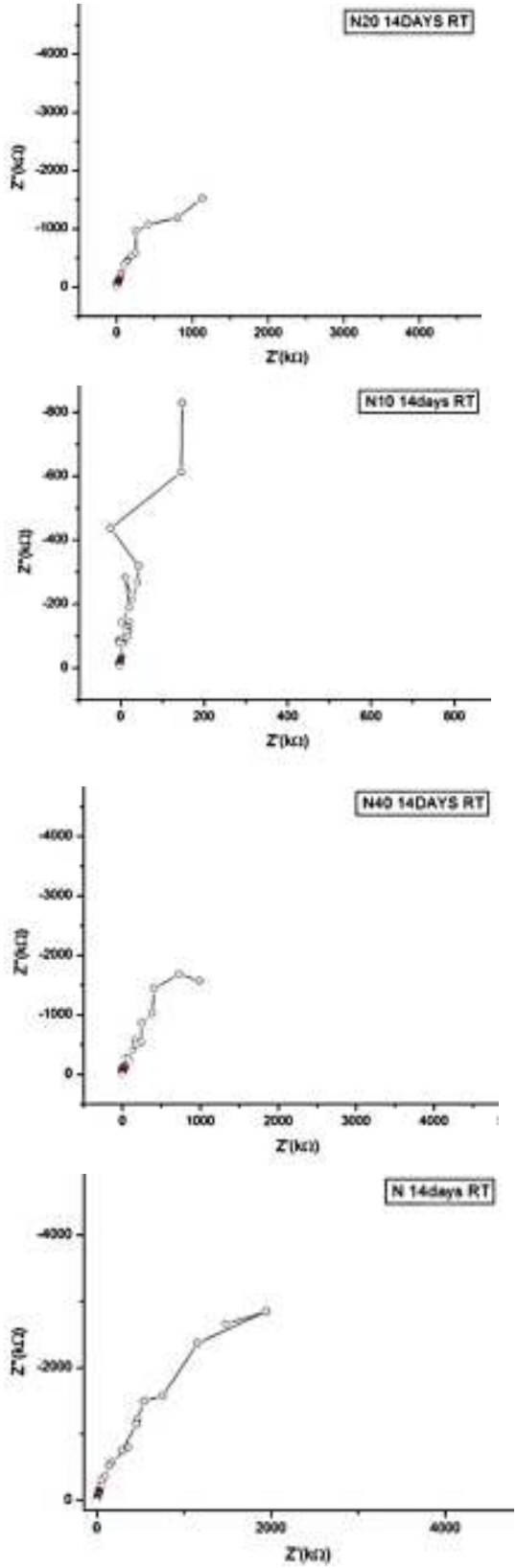

Figure 7: Study of electrical Behaviour of samples at 14 days.

CONCLUSION

1. From various characterization study test it is found that 70 % flyash achieves size less than 70 nm.
2. Compressive strength enhanced to 50% with 10 % nano-flyash than that of reference sample after 28 days
3. Flexural strength value of prism cast with 10% nano flyash enhanced to 15% more than that of the reference specimen after 28 days.
4. Mortars blended with 10% nano flyash particles absorbs 22% less water than normal specimen.
5. Improvement of compressive strength is due to improved microstructure and water absorption is also less.
6. From electrical impedance spectroscopy test it is clear that the cement paste samples blended with 10% n-FA particles offers maximum resistance towards the electricity.
7. Which concludes that the pore filling capacity of mortar/ paste is maximum at 10% nano blending. This improves the microstructure and also protects the structure from external ion penetration. Finally improving the life and durability of the structure
8. At present day we are in search for alternate materials which can be effectively achieved through emerging field of nano-technology.

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