ISSN: 2278-0181
ICADEMS - 2017 Conference Proceedings

Improvement of Concrete Strength and Enhancing the Resisting Property of Corrosion and Permeability by the Use of Nano Silica Flyashed Concrete

Anshu [1],
[1]Scholar,
Civil Engineering Department
Gitam Kablana, India

Mamta[2],
[2]Scholar,
Civil Engineering Deptarment
Gitam Kablana, India

Amit Singhal[3]
[3]Assitant Professor,
Civil Engineering Department
Gitam Kablana, India

This paper reviews the state of the field of Nanotechnology implementation in Civil Engineering. In order to reduce the carbon emission due to the cement manufacturing the fly ash is partially replaced in ordinary Portland cement and termed as Portland pozzolana cement (PPC) it not only reduces the environmental impact, improves the workability, corrosion strength and long term strength of concrete but this replacement of fly ash in the ordinary Portland cement deviating its strength consequently. Hence here we added Nano silica as an additive to fill up the deviation, and it is possible because the silica(S) in the sand reacts with calcium hydrate in (CH) the cement at Nano scale to form C-S-H bond and its improve the strengthening factor of concrete, which are in turn helpful in the achieving high compressive strength even in early days. This process which has proved to increase the strength may have a possibility of turning the concrete less alkaline because as the concentration of CH crystals is reduced the alkalinity of concrete will be reduced. This can induce corrosion in reinforcement bars. Hence we study the corrosion resistance property of nano silica added concrete. Also measuring permeability helps detect durability problems and allows timely and cost-effective protection of the concrete structure. Hence the recent progress and advancement in Nano-engineering and Nano modification in cement concrete is presented.

***Index Terms*—Nano Silica Flyashed Concrete, Fly ash, Nano silica, Calcium Silica Hydrate, Permeability**

I. INTRODUCTION

Concrete [1] is at something of a crossroads: there are many opportunities and some threats. For those opportunities to change into beneficial practice, engineers, material scientists, architects manufacturers and suppliers must focus on the changes that are required to champion concrete and maintain its dominance within the global construction industry.

Recent research has shown that a state of the art process for high-performance cement adds a new dimension to "classical" cement technology; similarly this is the time to work on "NANO TECHNOLOGY" for development of construction industry by innovations in concrete techniques. As concrete is most usable material in construction industry its been requiring to improve its quality. The main objective of this paper is to outline promising research areas.

II. WHAT IS NANO TECHONOLOGY?

"Nanotechnology [2] is defined as fabrication of devices or materials with atomic or molecular scale precision" nanotechnology is usually associated with study of material of micro size i.e. one billionth of a meter nanometer) or 10-9m.

III. DEFINITION OF NANO-CONCRETE

For discussions presented in this paper, Nano-concrete is defined as "A concrete made with Portland cement particles that are less than 500 Nano-meters as the cementing agent. Currently cement particle sizes ranges from a few Nanometers to a maximum of about 100 micro meters in the case of micro-cement the average particle size is 5 micro meters. An order of magnitude reduction is needed to produce Nano-cement. The SEM image of the Nano silica we had taken for our investigation is shown in Fig. 1

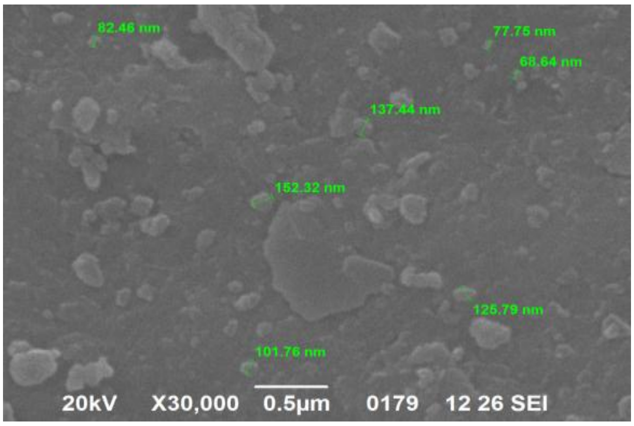


Fig. 1 The SEM image of Nano silica

IV. NANOSCALE CONCRETE

Fundamental research into the interactions between fly ash and the Nanostructure of Portland cement gel is under way, using neutron scattering technology. Nanotechnology is providing a close-up look at the hydration of cement grains and the Nanostructure of cement reactivity as hydrated surfaces develop on individual cements grains. The feasibility of cyberliths, or smart aggregates, as wireless sensors embded in concrete or soil is under examination. Concrete ills such as alkali-silica reactivity (ASR) and delayed stringier formation, the bane of concrete highways and bridges, are being explore at the molecular level using neutron-scattering technology and other processes.

A. Cement Reactivity at Nano Scale

We need to better know how to control the timing of concrete setting. The evolution of hydrogen profile shows the timing of the surface layer's breakdown. This information can be used to.

Study the concrete setting process as a function of time, temperature, cement chemistry, and other factors. For example, researcher used NRRA (Nuclear Resonance Reaction Analysis) to determine that in cement hydrated at 30^0 C, the breakdown occurs at 1.5 hours. The surface disintegration then releases accumulated silicated into the surrounding solution, where it reacts calcium ions to form a calcium-silicate hydrate gel, which binds cement grains together and sets the concrete. “This resolves a scientific debate that has been going on for more than a century.” The 20-nanometer-thick surface layer acts as a semi permeable barrer that allows water to enter the cement grain and calcium ions to leach out. However the larger silicate ions in the cement are trapped behind this layer. As the reaction continues, a silicate gel forms there, causing swelling within the cement.

V. OBJECTIVES OF THIS INVESTIGATION

To determine the improvement of compression Strength Corrosion resistance and Permeability strength of Concrete by Nano technology.

1. Studies on compressive strength, corrosion resistance and permeability strength of concrete were made separately by partially replacing of cement with fly ash and find ou the optimum replacement percentage of fly ash to the weight of cement.
2. Different proportion of replacing of fly ash with cement for studies are 0%, 10%, 20%, 30%, 40%, 50%, 60%, 70%, and 80%.
3. Same proportion of replacing of cement with fly ash with addition of Nano silica at a rate 2.5% to the weight of cement are done and their results are studied.
4. Then a comparative analysis of compressive strength
5. Corrosion resistance and Permeability factor of Partially Replaced Fly ash Concrete with the Nano Concrete.

VI. MATERIALS AND METHODS.

A. An investigation of Nano silica in cement hydration Process [2].

With the advent of nano technology [4], materials have been developed that can be applied to high performance concrete mix designs. Nano silica reacts with calcium hydroxide (CH) to develop more of the strength carrying structure of cement: calcium silica hydrate (CSH). In this paper, relationships have been developed to distinguish the benefits when using different sizes of nano silica in cement. An extensive regime of experimental analysis was carried out determine the effect of nano silica. Through these experiments the heat of hydration of multiple cement mix designs was measured. After that, the concentration of CH was recorded through X-ray diffraction. Then, the grain structures were examined through scanning Electron Microscopy, Finally, the compressive strength was determined for each cement paste mixture. Through these experiments it was found that as the silica particles decreased in size and their size distribution broadened, the CSHs became more rigid; this increased the compressive strength.

Specimen casting and curing

A laboratory type concrete mixture machine was used to mix the ingredients of concrete. The following procedure was followed in mixing.

First cement, fly ash and Nano silica were mixed one minute and after that the fine aggregate was also included and mixed and coarse aggregate was mixed thoroughly in dry state and cement were mixed for one minute.

Super plasticizer is mixed with water and it being added within two minutes now concrete was allowed to mix for three minutes.

All the specimen were well compacted using table vibrator, and cured for 7,14 and 28 days respectively.

This specimen casting is individually done and followed for Compression, Corrosion and Permeabilty setup.

VII. COMPRESSION TEST SETUP

This test is carried out on 150x150x150 mm size cubes [1] as per IS: 516-1959. The test specimens are marked and removed from the mould and unless required for test within 24 hours, immediately submerged clean fresh water and kept there until taken out just prior to test. A 2000 KN capacity Compression Testing Machine (CTM) is used to conduct the test. This specimen is placed between the steel plates of CTM and total load is applied at the rate of $140kg/m^3$/min and failure load in KN observed from the digital gauge.

A. Design of Concrete mix

The concrete mix are designed as per IS 10262-2009, the table below enumerates the summary of design results which fulfill the requirements as per the code standard.

STEP NO	PARAMETER		M_{40}
1.	Target mean strength (N/mm^2)		48.25
2.	Water/cement ratio		0.45
3.	Quantities	Water content (lit/m^3)	140
		Sand (%)	38
4.	Final water content (kg/m^3)		140
5.	Actual cement content (kg/m^3)		350
6.	Check for minimum cement content (kg/m^3)		320
7.	Aggregate Quantity	Fine aggregate (kg/m^3)	862
		Coarse aggregate (kg/m^3)	1097
8.	Mix proportion		0.45:1:1.65:2.92

Table 1. According to IS 10262-2009 concrete mix design (M40)

B. Specimen details

This experimental program consist of casting and testing of 162 concrete cubes of standard size of 150mm x 150mm x 150mm.

Number of cubes casted, their id, description and their curing period are summarized below.

CUBE ID	FLY ASH REPLACEMENT	NO OF CUBES FOR		
		7 Days curing	14 Days curing	28 Days curing
C	0%	3	3	3
F 1	10%	3	3	3
F 2	20%	3	3	3
F 3	30%	3	3	3
F 4	40%	3	3	3
F 5	50%	3	3	3
F 6	60%	3	3	3
F 7	70%	3	3	3
F 8	80%	3	3	3

Table 2. Table shows the specimen details of partially specimen details of partially replaced fly ash concrete

CU BE ID	FLY ASH REP LAC E- ME NT	NANO SILIC A AS ADDIT VE	NO OF CUBES FOR		
			7 Days curing	14 Days curing	28 Days curing
C	0%	2.50%	3	3	3
F 1	10%	2.50%	3	3	3
F 2	20%	2.50%	3	3	3
F 3	30%	2.50%	3	3	3
F 4	40%	2.50%	3	3	3
F 5	50%	2.50%	3	3	3
F 6	60%	2.50%	3	3	3
F 7	70%	2.50%	3	3	3
F 8	80%	2.50%	3	3	3

Table 3. Table shows the specimen details of concrete cube

The results obtained from the above elaborative experiments are discussed. The results of mechanical strength properties such as cube compressive strength have discussed and the compression strength variation for 7, 14 and 28 days cured concrete cubes of only fly ash replacement and fly ash replacement with Nano silica as additive are also analyzed.

VIII. CORROSION TEST SETUP

The test was carried out on 150 x 300 mm [3] size concrete cylinders with a rod of height 450 mm in the center throughout the specimen. The test specimen are marked and removed from the moulds after 24-48 hours from casting depending upon the percentage of fly ash and submerged in clean fresh water for curing. The impressed current technique which is commonly used for accelerating reinforcement corrosion in concrete specimen was used for testing. The specimen was placed in water bath containing calculated quantity of dissolved sodium chloride (table salt) to act as electrolyte. Calculated voltage of current was passed through the concrete specimen till the concrete cracks. The percentage weight loss in rebar and the width of cracks in concrete were studied.

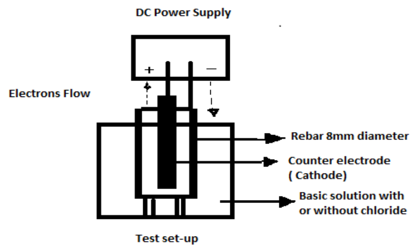
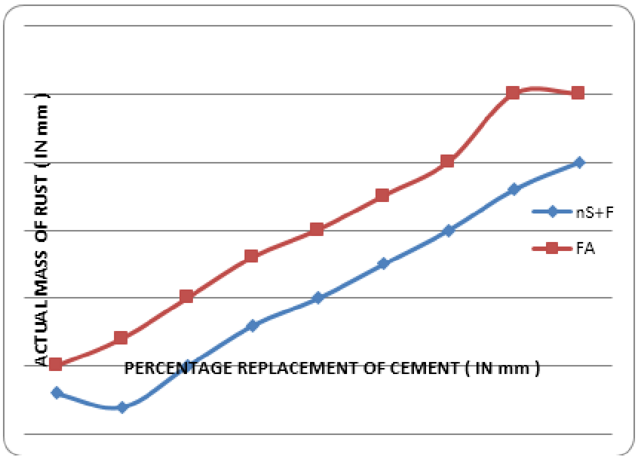


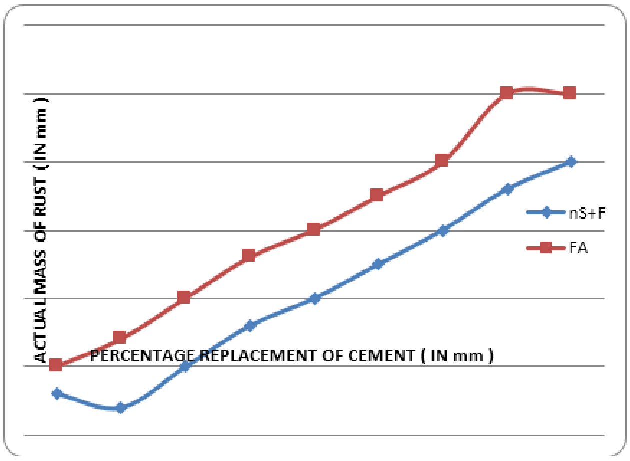
Fig 2. Impressed current test setup

A. Results attained for corrosion test

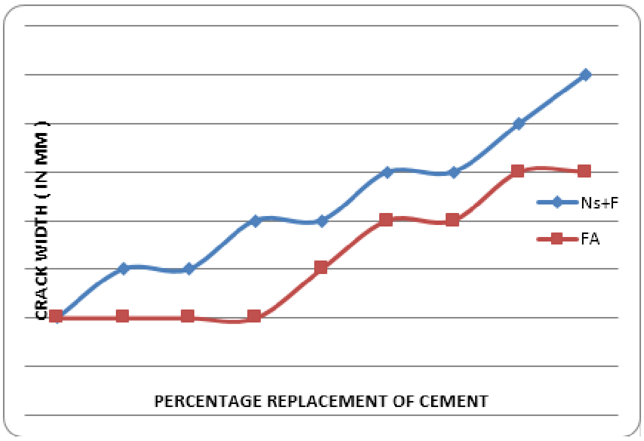
The testing was carried out using the Test Set Up and the graphs for the compression of Mass of Actual Rust, Degree of Induced Corrosion and Crack Width between the Fly Ash added concrete and nS + fly ash added concrete are plotted.



Graph 1. Actual mass of rust comparison result for (M40) days



Graph 2. Degree of induced corrosion comparison Results for (M_{40}) 28 days



Graph 3. Crack width comparison results for (M_{40}) 28 days

IX. PERMEABILITY TEST SETUP

The test is carried out on 150 x 150 x 150 mm size [5]cube, as per IS: 3085-1963. The test specimen are marked and removed from the mould and unless required for test within 24 hours, immediately submerged clean fresh water and kept there until taken out just prior to test.

The standard test procedure head to be applied to the water in the reservoir should be 10kg/cm2. This may be, however be reduced up to 5 kg/vm2 in the case of relatively more a reasonable time, and may be increased up to 15kg/cm2 for relatively less permeable specimen.The quantity of percolate and the gauge-glass readingshall be recorded at periodic intervals. In the beginning, the rate of water intake is larger than the rate of outflow. As the steady state of flow is approached, the two ratestend to become equal and the outflow reaches a maximum and stabilizes. With further passage of time, both theinflow and outflow generally resister a gradual drop. Permeability test shall be continued for about 100 hours after the steady state of flow has been reached and the outflow shall be considered as average of all the outflows measured during this period of 100 hours.

RESULTS

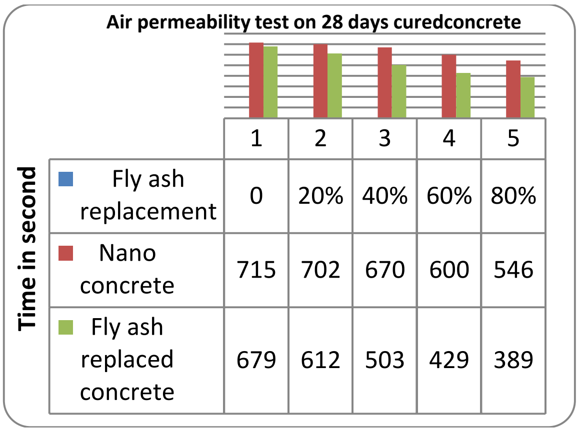


Fig 3: Permeability strength comparison of 28 days cured specimen

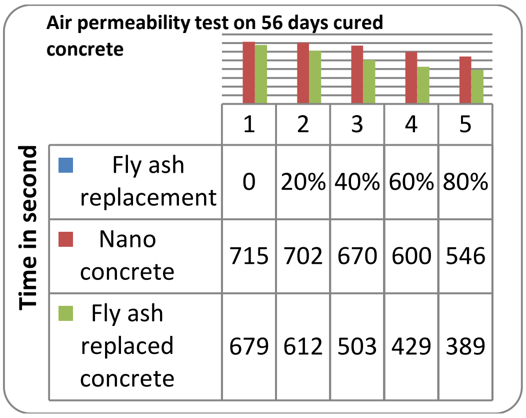


Fig 4: Permeability strength comparison of 58 days cured specimen

TIME IN SECOND	INTERPRETATION
<30	Poor
30 – 100	Moderate
100 – 300	Fair
300 – 1000	Good
>1000	Excellent

Fig 5 : Interference of the Permeability results

DISCUSSION

1. The permeability of concrete attained by adding fly ash and Nano silica in the partial replacement of cement possess some significant higher strength.
2. Nano silica consumes calcium hydroxide crystal, Reduces the sizes of the crystal at the interface zone and transmute the calcium hydroxide feeble crystals to the C-S-H crystals, and improves the interface zone and cement paste structure.
3. The water absorption test indicate that the Nano- silica concrete has better permeability resistance than the normal concrete. Due to the microstructure of the Nano silica concrete is more uniform and denser than that of reference concrete as shown in The SEM test.

4. Permeable strength of the concrete increase with the Nano-silica, especially at early ages. However the early strength of the concrete decreases slightly with adding the fly ash, but decreases at later ages. These results indicate that the Nano silica may adopt for higher strength green concrete technologies.

X. CONCLUSION

From the above experiments and results we safely conclude the points as follow.

- Nano concrete could control the carbon dioxide emission from the earth which is shown by using fly ash concrete products instead of cement concrete.
- Thus the Nano particles which is in the form of silica can easily react with cement particles which are normally in Nano sacle initiate the CSH reaction and hence its tends to accelerate the compressive strength of concrete.
- Nano-silica consumes calcium hydroxide crystals, reduces the size of crystal at the interface zone and transmute the calcium hydroxide feeble crystal to the C-S-H crystals, and improves the interface zone and cement paste structure.
- D. Compressive strength of concrete increases with adding the Nano silica, especially at early ages. However the early strength of the concrete decreases slightly with adding the fly ash, but decreases at later ages. These results indicate that the Nano sililca may adopt for higher strength green concrete technologies.
- Corrosion resistance property of the nS added concrete is comparatively higher than ordinary fly ash concrete.
- The corrosion resistance of optimum percentage replacement of fly ash is higher in nano concrete than the ordinary fly ash concrete The average increase in compressive strength up to 7% than the compressive strength ordinary partially replaced fly ash concrete on 7 days cured concrete.
- But in the fourteen days cured cubes the increase in compressive strength is incrementally up by 13% percentage compared to the ordinary partially replaced fly ash concrete.
- Finally the compressive strength of twenty eight days cured Nano concrete possess an incremental strength by 23% than the ordinary fly ash replaced concrete.
- The permeability of concrete attain by adding fly ash and Nano silica in the partial replacement of cement possess some significant higher strength.

REFERENCES

[1] Balaguru P.N. (2005), “Nanotechnology and Concrete Background, Opportunities and Challenges.”Proceeding of the International Conference-Application of Technology in Concrete Design.
[2] Boresi Arthur Chong ken P.; Saigal, Sunil. “Approximate Solution Methods in Engineering Mechanics”,John Wiley, New York, 2002, 280pp.
[3] Balaguru P.; and Shah, S.P. Fiber Reinforced Cement Composites”, McGraw-Hill, New York, 192,530pp.
[4] Srivastava, D.; Wei, C.; and cho, K. “Nanomechanics of carbon Nanotubes and composites.”Applied Mechanics, Review,56, 2003, 215-230.
[5] LI, G. “Properties of high-volume fly ash concrete incorporating Nano-SiO2”. Cement and Concrete, Research 34, 2004 P 1043-1049.