**EFFECT OF MICRO AND NANO PARTICLES TO IMPROVE THE STRENGTH AND CORROSION RESISTANCE OF CONCRETE**

***P.Vinothkumar1, B.H.Ramathilagam2, M.Velmurugan3***

***1 Assistant Professor, Department of Civil Engineering, Sree Sowdambika College of***

***Engineering, Aruppukottai, Tamilnadu E-Mail: vinothk539@gmail.com***

***2 Assistant Professor, Department of Civil Engineering, Sree Sowdambika College of***

***Engineering, Aruppukottai, Tamilnadu E-Mail: ramathilagambh@gmail.com***

***3 UG student, Department of Civil Engineering, Sree Sowdambika College of***

***Engineering, Aruppukottai, Tamilnadu E-Mail: velmurugan.m12303@ gmail.com***

***ABSTRACT:* This project is aimed to study the Effect of Fly ash and Nano Silica in concrete to improve the Physical, Mechanical and Corrosion resistant properties. Activated fly ash certainly improves the early age strength and durability of concrete and corrosion tolerance. Many methods such as physical, thermal and chemical activation are used to activate the fly ash. In chemical activation the chemicals like sodium hydroxide (NaOH) and calcium oxide (CaO) are used to activate the fly ash. Replacement of cement by activated fly ash with addition of Nano silica, 0.5% to the weight of cement and fly ash. Super plasticizer of Polycarboxylate type was added to enhance the workability and the dispersion of Nano particles during mixing. Concrete specimens prepared with 10%, 20%, 30%, 40% and 50% of activated fly ash replacement levels of OPC and adding 0.5% of Nano silica. Electro chemical techniques were used to study the corrosion resistance properties of activated fly ash blended cement. Results were compared with OPC and tolerable limit of Replacement of activated fly ash was identified.**

Keywords: Activated fly ash, methods of fly ash activation, blended cement, Nano silica, corrosion resistance

1. ***INTRODUCTION***

Numerous researches related to the use of pozzolanic material in preparation of mortar and concrete have been conducted over the years. Certain researches investigate the possibility of replacing Ordinary Portland Cement (OPC) partially by pozzolanic material in preparing blended cements.

Concrete is one of the most widely used construction materials; it is usually associated with Portland cement as the main component for making concrete. The demand for concrete as a construction material is on the increase.

The climate change due to global warming, one of the greatest environmental issues has become a major concern during the last decade. The global warming is caused by the emission of greenhouse gases, such as CO2, to the atmosphere by human activities. Among the greenhouse gases, CO2 contributes about 65% of global warming. The cement industry is responsible for about 6% of all CO2 emissions, because the production of one ton of Portland cement emits approximately one ton of CO2 into the atmosphere.

Electricity is the key for development of any country. Coal is a major source of fuel for production of electricity in many countries in the world. In the process of electricity generation large quantity of fly ash get produced and becomes available as a by-product of coal-based power stations. It is a fine powder resulting from the combustion of powdered coal - transported by the flue gases of the boiler and collected in the Electrostatic Precipitators (ESP).

 Fly ash is among the commonly used mineral admixtures as it is available in large quantity in many developing countries. Similarly the high volume fly ash blended cement which is now in use gives increasing strength with ageing.

Recently, Nano particles have been gaining increasing attention and have been applied in many fields to fabricate new materials with novel functions due to their unique physical and chemical properties. Nano silica and clinker, as well as Nano fibers, used to increase mechanical properties and durability of cementations materials. Service life can be doubled through the use of Nano-additives. The workability of concrete get increased by Nano particles.

***FLYASH GENERATION AND UTILIZATION IN INDIA***

The table1 also shows that the rate of generation of fly ash far exceeds the incremental growth rate of its utilization. In the next three or four years the target of 100 per cent utilization of fly ash likely to be generated is by itself a daunting task. If one considers the expected generation of fly ash over the next two decades, the volume projected is gigantic and its utilization programme will have to be far more challenging than what is perceived today. It is also obvious that no niche utilization strategy would work and one will have to look for newer avenues of bulk usage.

 **Table:1 Fly Ash Generation and Utilization in India**

|  |  |  |
| --- | --- | --- |
| **Year** | **Generation Mt** | **Utilization** |
| **Mt** | **Percentage**  |
| 1993-94 | 40 | 1.2 | 3 |
| 2004-05 | 112 | 42 | 38 |
| 2006-07 | 130 | 60 | 46 |
| 2011-12 | 170 | 170 | 100% utilization is mandated. Not yet planned |
| 2031-32 | 600 | ---- |

The development and use of mineral admixture for cement replacement is growing in construction industry mainly due to the consideration of fast construction, cost savings, environmental protection, and low consumption of resources and utilizing the bye products that are available. Mineral admixture generally used is raw fly ash, rice husk ash, metakaoline, silica fume, geopolymers etc. Addition of such materials improves the concrete and mortar property. The fly ash is among the commonly used mineral admixtures which is available in large quantities in many developing countries. As per the estimation of Government of India, power plants are going to use 1800 million tons of coal that may result 600 million tons of fly ash by 2031-2032.

***2. EXPERIMENTAL***

***2.1. Materials used***

***Cement***: Ordinary Portland cement of (43 grade cement) confirming to IS: 8112-1989 is used. Table 2 shows the properties of cement and Fly ash.

***Fine Aggregate****:* Natural River Sand of size below 4.75mm confirming to zone II of IS 383-1970 is used as fine aggregate.

***Coarse Aggregate***: Coarse aggregate used in this study consist of crushed stone of size 12mm and below.

The specific gravity of fine and coarse aggregates are 2.64 and 2.63 respectively. Water absorption of fine and coarse aggregates are 0.5% and 0.1% respectively.

**Table: 2 Properties of Cement and Fly ash**

|  |  |  |
| --- | --- | --- |
| **Properties** | **OPC** | **Fly ash** |
| SiO2 | 20-21 | 64.43 |
| Al2O3 | 5.2-5.6 | 20.67 |
| Fe2O3 | 4.4-4.8 | 6.00 |
| CaO | 62-63 | 1.25 |
| MgO | 0.5-0.7 | 0.8 |
| Loss on ignition  | 1.5-2.5 | 1.6 |

***Superplasticizer****:* polycarboxylate is based on Sulphonated Naphthalene Polymer and supplied as brown liquid instantly dispersible in water.

***Nano silica:*** The particle size of the Nano silica is as follows

Range of size 35 nm to 46 nm

Average size 41 nm

Diameter of Nano silica 42 nm



**Fig:1 The SEM image of Nano silica**

The mix proportion used for casting is as follows: 1:0.984:2.95

OPC 450 kg/m3

Fine aggregates 444 kg/m3

Coarse aggregates 133 kg/m3

Water–cement ratio 0.40

Fly ash 10%,20%,30%,40% and50% replacement level of OPC by weight of cement

Nano silica 0.5% to the weight of cement and fly ash

***2.2. Fly ash used***

The fly ash collected from Tuticorin Thermal power Station, Tuticorin, Tamilnadu, India was used for the entire study. Fly ash is used in the unprocessed form and as well as in the processed form produced by physical, chemical and thermal methods.

***2.3. Physical activation***

The fly ash as-received was sieved to remove any coarser and foreign particles and then mechanically ground in a ball mill to a fine powder. The particle size distribution measured was found to be between 40 and 90 µm.

***2.4. Thermal activation***

Finely ground fly ash was kept at a temperature of about 1000°C in a graphite pot for 1 h. After cooling at room temperature, the finely ground fly ash was used for investigation. The carbon, sulphur and other impurities are removed by thermal activation.

***2.5. Chemical activation***

Finely ground fly ash was subjected to chemical activation by treatment with sodium hydroxide solution, filtered and dried. Further, calcium oxide (1% by weight of cement) was added to the concrete during mixing.

The mechanism of transforming non-cementitious fly ash into a cementing compound in an OPC-based environment as follows. OPC reacts with water and forms the cementing compound, the chemical name of which is ‘Calcium Silicate Hydrate’ (CSH). At the same time calcium oxide in OPC is transformed in to Calcium Hydroxide. When fly ash is mixed with OPC, during the hydration process, the Calcium Hydroxide in the OPC paste reacts with fly ash and form Calcium Silicate Hydrate, which is the same cementing compound produced by OPC. The above mechanism is illustrated in Fig. 2.

****

**Fig. 2:** Transformation of fly ash into CSH in an OPC-based environment

As a starting point, mixture of fly ash and quick lime (calcium oxide) is considered. When water is added to this mixture, calcium oxide reacts with water and forms Calcium Hydroxide. In this alkali environment, non-cementitious fly ash is transformed into a cementitious compound. The mechanism is illustrated in Fig. 3.





**Fig. 3:** Transformation of fly ash into CSH in an APC-based Environment

The activated fly ash particle is smaller than that of cement particles, which can increase the degree of connection (Fig.2) and form inhomogeneous coagulation among cement particles promoting cement setting.



**Fig.4:** Fly ash and activated fly ash effects on cement particles connection (*n*, number of connecting points)

***2.TEST PROGRAM***

***2.1. Compressive strength test***

100mmx100 mmx100mm concrete cubes were cast using 1:0.984:2.95 mix proportion with w/c ratio of 0.40. Specimens with OPC (control) and OPC replaced by fly ash (as-received as well as activated) at 10%, 20%,30% and 40% replacement levels and adding nano silica were cast. During moulding, the cubes were mechanically vibrated. After 24 h, the specimens were removed from the mould and subjected to water curing for 28 days. After curing, the specimens were tested for compressive strength using a compression testing machine of 1000 kN capacity. The tests were carried out on six specimens and average compressive strength values were obtained.

***3.2 ELECTROCHEMICAL STUDIES***

***3.2.1. Weight loss measurements***

Cylindrical mortar specimen of size 55 mm diameter and 60mm height were cast using OPC and OPC containing various activated fly ashes at 10%, 20%, 30% ,40% and 50% replacement levels. Mild steel rod of 12 mm diameter and 40 mm long was embedded centrally. Initially the steel rebar samples were cleaned in hydrochloric acid, degreased with acetone and washed with double distilled water and dried. The initial weight of the rebar sample was taken before casting for gravimetric weight loss measurements.

After the curing period was over, all the specimens were completely immersed in 3% NaCl solution. The specimens were maintained in the same condition for 15 days and then subjected to drying for another 15 days. One alternate wetting and drying cycle consists of 15 days immersion in 3% NaCl solution and 15 days drying in open air at room temperature. In order to induce the accelerated corrosion 3% NaCl solution was used.

***3.2.2. Rapid chloride ion permeability test***

The resistance to chloride ion penetration in terms of total charge passed in coulombs through blended concrete specimens after 28 days of moisture curing was measured as per ASTM C 1202. This test was conducted as per ASTM C1202-94. Concrete disc of size 95 mm diameters and 50 mm thickness were cast and allowed to cure for 28days. After 28 days of curing, the concrete specimens were subjected to RCPT test by impressing 60 V as shown in Fig.5

******

 **Fig.5: RCPT setup**

***3.3.3 IMPREESED VOLTAGE TEST***

Cylindrical concrete specimens of size 50mm dia and 100mm height were casted,with centrally embedded rebars of 12mm dia and 70mm height.after curing specimens were demoulded and subjected to impressed voltage test.in this techniq,the concrete were immersed in 3% NaCl solution and embedded steel in concrete is made anode with respect to an external stainless steel electrode serving as a cathode by applying a constant positive potential of 12V to the system from a DC source.The variation of current is recorded with time.for each specimen,The time taken for initial crack and the corresponding maximum anodic current flow were recorded.

****

 **Fig.5: Impressed voltage setup**

***3.2.3 OPEN CIRCUIT POTENTIAL (OCP) MEASUREMENTS***

The OCP values for the different systems were periodically monitored using a voltmeter with a high input impedance of 10 mega ohms. A saturated calomel electrode (SCE) was used as the reference electrode. The positive terminal of the voltmeter was connected to the working electrode i.e., the embedded steel (TMT). The common terminal was connected to the reference electrode. The corresponding potentials were recorded. The OCPs for all of the specimens were monitored over an exposure period of 120 days. In this study, triplicate specimens were used for each system and the average of these values were reported and interpreted based on ASTM C -876-1994.

******

**Fig.6: OCP Test**

***CONCLUSION***

Replacement of cement with fly ash is very advantageous from the point of view of ecological impact.

As green building material, fly ash is advantageous to solving the question of environmental protection and energy conservation.

All the three methods, physical activation, thermal activation and chemical activation have good effect, and have its own advantages and disadvantages. While considered in all aspects, pulverization activation and combination of these activation methods are better than the others.

***REFERENCES***

[1] Anita Sharma, Khushboo Srivastava, Vijay Devra and Ashu rani “Modification in properties of fly ash through mechanical and chemical activation” American Chemical Science Journal 2(4): 177-187(2012)

[2] Hemant Chauhan and Bhavna K. Shah “Effect of activated flyash in metakaolin based cement”National Conference on Recent Trends in Engineering & Technology 13-14 May 2011

[3] Jae Eun Oh, Juhyuk Moon, Sang-Gyun Oh, Simon M. Clark, Paulo J.M. Monteiro “Microstructural and compositional change of NaoH-activated high calcium fly ash by incorporating na-aluminate and co-existence of geopolymeric gel and C–S–H (I)” Cement and Concrete Research 42 (2012) 673–685

[4] Li, D; Chen, Y, Shen, J; Su, J; Wu, X “The influence of alkalinity on activation and microstructure of fly ash" Cement and Concrete Research, 30, (2000) 881-886

[5] McCarthy, M.J. and Dhir, R.K. (2005). Development of high volumefly ash cements for use in concrete construction. Fuel, 84, 1423-1432.

[6] Mostafa Jalal, Ali Reza. Pouladkhan, Hassan Norouzi, Ghobad Choubdar “Chloride penetration, water absorption and electrical resistivity of high performance concrete containing nano silica and silica fume” Journal of American Science (2012)

[7] P.N Magudeswaran, Malathi .M and Sunilaa George “Activated fly ash blended cement” Asian Journal of Chemistry, vol.20 No.1, pp21-24, 2008.

[9] Palomo, A; Grutzeck, M.W; Blanco, M.T.(1999). Alkali-activated fly ashes : *A Cement for the future*. Cement and Concrete Research, 29, 1323-1329.

[10] Rudolf Hela, Lenka Bodnarova and Denisa Orsakova “Mechanically activated fly ash and its influence on properties of fresh and hardened concrete”*37th Conference on Our World in Concrete & Structures August 2012*

[11] Song,H.W., Saraswathy,V., “Corrosion Monitoring of Reinforced Concrete Structures– A Review”. 2007

[12] Sunilaa George and R.Thenmozhi “Flexural behaviour of activated fly ash concrete” International Journal of Engineering Science and Technology Vol. 3 No. 10 October 2011

[13] Quan Jueshi, shi Caiijun and Wang Zhi. “Activation of blended cements incorporating fly ash”, Cement and Concrete Research, vol.31, pp.1121-1171, 2001.

[14] G.Queric and H.J.H.Browers “Application of Nano-silica (nS) in concrete mixtures” 8th fib PhD Symposium in Kgs. Lyngby, Denmark” June 20 – 23, 2010