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Review on Performance of Fly Ash based Geopolymer Concrete Using Nano Technology

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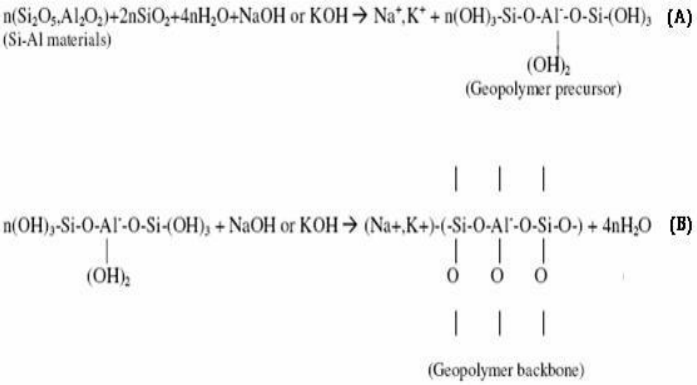
Abstract- **Rapid urbanization depends on basic infrastructural facilities. The National Housing and Habitat Policy evolved in 2007 stressed on utilization of eco friendly materials in construction field. From the construction point of view the demand of concrete is increasing day by day for satisfying the need of development of infrastructure facilities. It is a well established fact that the production of OPC not only consumes significant amount of natural resources and energy but also releases substantial quantity of Carbon dioxide to the atmosphere. Therefore, it is essential to find alternatives to make the concrete environment friendly. Geo polymer is an inorganic alumina-silicate compound, synthesized from fly ash. The fly ash, one of the industrial waste material from Thermal power plants becomes a source material for Geo-polymer binders, is available abundantly in India, but to date its utilization is limited. Hence it is essential to make the efforts to utilize this by-product in concrete manufacturing, which was suggested in Energy Conservation Building Code ECBC 2009. The experimental work on Geo-polymer concrete by using of fly ash to evaluate the effect of various parameters affecting its strength and durability of concrete in order to enhance its overall performance was carried over. The addition of naphthalene based Superplasticizer improves the workability of fresh geo polymer concrete. By applying the Nano Technology, Nano silica and Nano carbon is added to improve the strength of concrete. The main objective of this study with review of literatures is to analyze the carbon dioxide free cementitious material, its various properties and their effects on Geopolymer concrete.**

Keywords : *Fly ash, Geopolymers, Alkaline liquid, Nano materials, Strength and durability.*

I. INTRODUCTION

Geopolymers are alkali activated alumina silicate binders formed by the reaction of silica and alumina with alkali solutions at a relatively low elevated temperature in the environment of about 60-80°C.It is essentially concrete without cement i.e. cement free concrete. Portland cement production emits a huge amount of CO_2ie.Approximately 1 ton of OPC production releases 1 ton of CO_2.India is the second larger producer of cement and by 2025 it is expected that it will surpass even China's when our population exceeds that of China, however, if both per capita cement consumption equals. With such a looming carbon footprint and with the generation of electricity being overwhelmingly dependent on combustion of coal it is expected that India in near future will have to impose a CO_2 tax in order to meet its revenue demands. The Planning Commission of India says a 100% utilization of flyash for the next three to four years but with the current stagnation of 50% utilization, mainly due to the cement companies, it is expected that our commercial application of geopolymer concrete using flyash sets pace from the present domain of research.The reaction of fly-ash with an aqueous solution contains NaOH and Na_2SiO_3 in their mass ratio, results in a material with 3D polymeric chain and ring structure consisting of Si-O-Al-O bonds. The schematic formation of geo-polymer material can be shown as described by Equation A and B.



Geo polymers are amorphous semi-crystalline and crystalline structure of Al-Si particle (Davidovits,1991).

II. PROPERTIES OF ALKALI SOLUTION

The main components of the alkali solution are :

a. Sodium Hydroxide

Physically Sodium Hydroxide is looking like soda which is almost white in colour. In market it is available with different purity content. Cost of Sodium Hydroxide is also vary with the purity of the substance. Since geo-polymer concrete is homogeneous in nature and the material is also homogeneous and its main work is to activate the sodium silicate, so it is recommended to use a purity level of 94% to 96% i.e. a low cost sodium hydroxide.

ISSN No: - 2456 – 2165

b. **Sodium Silicate**

Physically it looks like a gel like liquid, which is also known as water glass or liquid glass. It is the most important material in the alkali solution. Because of different percentage of Na_2O, the strength of geo-polymer concrete varies. With 8% Na_2O in sodium silicate gives good result i.e. almost 45 MPa with a curing temperature of 45^0C.

III. APPLICATIONS OF GPC

It can be highly used in any kind of structural construction work due to its high early strength and high compressive strength than the conventional OPC concrete. It can be used in any kind of rehabilitation works, road repair works due its high early strength gain. Fly-ash based geo-polymer bricks are also highly appreciated now-a-days because it uses waste materials like fly ash. Geo-polymer cured at high temperature almost of 60^0 to 90^0C for 24hrs during 24 to 48 hrs of casting.

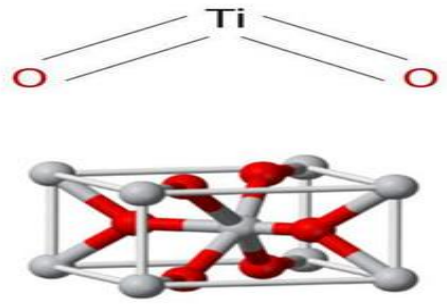
Nano silica(SiO_2)

Addition of nano-silica(NS) in cement paste and in concrete can shows the high results. One is size effect, i.e. primarily based on their particle nature, which makes it useful as filler material and second is the chemical pozzolanic activity, capability of reacting with calcium hydroxide and water of the cluster compounds. There are different methods to synthesis nano silicon dioxide. Unit Sol-gel method, Electric-Arc-method, biological methodology, precipitation methodology and various production methodologies. Nano SiO_2 may be directly prepared from bio waste like Rice Husk ash. Nano silicon dioxide can increase the density of concrete. It is also reduces porosity of concrete and improves the bond between cement matrix and aggregates with higher compressive and flexural strength.

NANO Titanium Dioxide(TiO_2)

By using of Nano TiO_2 can shows the differences in compressive strength, workability and setting time of concrete. The decrease in workability and delays in setting time is found in the presence of nano particle blended concrete. Based on the studies of the effect of limewater on flexural strength and water permeability of TiO_2 nano particles blended concrete. A vital accomplishment in flexural strength and water porosity of concrete with nano particle in the lime water set was ascertained, however, there was no extended improvement in compressive strength.

Nano-Silica



Titanium-dioxide

IV. APPLICATIONS - NANOTECHNOLOGIES FOR CONSTRUCTION

Nanotechnology can apply in paints to assure the corrosion and protection under insulation since. It might also protect the metal from attack of chloride. Other applications refer to coatings that have self healing capabilities through a method of "self assembly". It can also be worked as coating material for self cleaning and it is suitable for road ways also.

Nanotechnologies for fire Protection

A nano cement coating on building material method usually provides fire resistance of steel structures. Nano-cement (made of nano sized particles) has the potential to make a troublesome, durable, heat coatings. This can be achieve by the blending of carbon nanotubes with the cementious material to fabricate fiber composites which will inherit a number of the outstanding properties of the nanotubes.

V. LITERATURE REVIEWS

Joseph davidovits (1991) discussed the result of antheceramic material in their structure and properties. These materials can poly condense just like organic polymers, at temperature lower than 100^0cgeopolymerization of the chemical reaction alumina-silicate oxides(A13+in iv-fold co ordination) with alkaline polysilicates, yielding polymeric si-o-a1 bondstheamorphous to semi –crystalline three dimensionalsilico-aluminate structure.

Iijima(1991) has studied about tubular form of carbon reported named carbon nanotubes (CNTs). These nanotubes consists of several graphitic shells with adjacent shell separation of 0.34 nm, diameters of a few nanometers, and high length/diameter ratio. About two years later, he reported the observations of single-walled carbon nanotubes (SWCNTs), which consist of a single graphite sheet seamlessly wrapped into a cylindrical tube. CNTs can be produced by various techniques such as arc discharge, laser ablation, thermal and plasma enhanced chemical vapor deposition (CVD), and many other recently developed methods. CNTs possess outstanding properties such as the

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highest Young's modulus (1.4 TPa), tensile strength (above 100 GPa), current density (10^9 A/cm^2), and thermal conductivity (above 3000 W/mK) among the known materials. Additionally, CNTs are flexible and have high breaking elongation (20–30%).

Yasirsofi and IftekarGull intended to study the properties of fly ash based Geopolymer concrete.M20grade GPC can be formed by adopting nominal mix of 1:1.5:3,fly ash: fine aggregates: coarse aggregates, by varying alkaline liquid to fly ash ratio from 0.3 to 0.45. The compressive strength, tensile strength and flexural strength tests were conducted on geopolymer concrete and parameters that affects analyzed and proved experimentally. The durability properties like permeability and acid attack are also studied. From the test results, it was concluded that geopolymer concrete possesses good compressive strength and offers good durability characteristics. With the increase of alkaline liquid to fly ash ratio strength decreases and alkaline liquid to fly ash ratio less than 0.3 is very stiff.

M. Sarkar described compressive strength of fly ash based geopolymer mortar samples having molar concentration of 8 (M) without nano silica (with heat curing) and 4% ,6%,8% and 10% of nano silica (with-out heat curing). The strength of controlled sample (cement and sand) made with OPC cement is also compared. It is well accepted that the strength of geopolymer mortars without nano silica and cured at 60 LC for 48 h were more than conventional control cement mortar of cement and sand ratio 1:3 at all ages. The compressive strength of geopolymer mortars with or without nano silica is more at higher molar concentration due to the higher rate of alkali activation.

Bhuvaneshwari and Sapthashi Sasmal have studied about the Conventional concrete improved by applying nanotechnology aims at developing a novel, smart, eco- and environment- friendly construction material towards the green structure. Today's life, though utilization of cement based materials plays a vital role in the infrastructure development, it is polluting the environment by emitting CO_2. Based on this view, researchers have been pursuing to evolve new or alternate material towards a green and sustainable solution. It also discusses the application of nanotechnology in the area of cement based materials, their composites. It has been observed that the inclusion of nano particles would improve the toughness, shear, tensile and compressive and flexural strength, durability of cement based materials, better understanding and engineering of complex structure of cement- based material at nano-level.

SudiptaNaskar, Arun Kumar Chakraborty discussed in Effect of nano materials in geopolymer concrete about compressive strength of geopolymer concrete with addition of nano silica (0.75%, 3%, 6%), 0.02% multi-walled carbon nano tube (CNT) and also with 1% titanium di-oxide (TiO_2). The strength of geopolymer concrete in control condition was also compared. However, addition of nano materials in the low calcium fly ash based geopolymer concrete seems to provide comparable compressive strength. It was shown that geopolymer concrete with addition of 0.75% nano silica provided almost 80% of the compressive strength at 7 days but at 28 days the strength seemed to be decreased whereas 3% and 6% nano silica addition did not provide satisfactorily compressive strength at 7 and 28 days. In case of 0.02% carbon nano tube addition with geopolymer concrete 7 and 28 days compressive strength was not also quite satisfactorily.

S. Ridha, M. Akmalludin and S. S. Salehudin expressed inclusion of nano material in cement system has various advantages in overcoming poor crack resistance, acid resistance and low strength. Common nanomaterials used in cement system are nano-SiO_2, ZnO_2, Al_2O_3, TiO_2, carbon nanotubes, nano-clays, carbon nanofibers and other nanomaterials. Among those types of nanomaterials, this study will utilize nano-SiO_2 whereas it gives enhanced mechanical properties (compressive strength), lower porosity and permeability. The amounts of admixture of nano-SiO_2 in three geopolymer cement samples are 1%, 3% and 5%. Addition of nano-silica results in a substantial increase in compressive strength. As indicated in XRD analysis that the addition of nano-SiO_2 transform the port landite (CH) to calcium silicate hydrate (C-S-H) and to bermorite at HPHT condition. This phenomena can helps in preventing strength retrogression and provides low permeability.

Ashwani K. Rana, Shashi B Rana, AnjnaKumari (2009) described that Nanotechnology is one of the most active research areas that encompass a number of disciplines including civil engineering. Traditionally, nanotechnology has been concerned with developments in the fields of microelectronics, medicine and materials sciences. However, the potential for application of many of the developments in the nanotechnology field in the area of construction engineering is growing. The potential application of various nanotechnology developments in the civil engineering field is discussed, and the potential for further basic research that may lead to improved system is evaluated.

NurYazdani, VinothMohanam (2014) expressed Carbon nano-materials, especially Carbon Nanotubes (CNT) and Carbon Nanofibers (CNF), are two of the most prospective advanced materials in cement based products for the construction industry. Both CNT and CNF composites demonstrated significant increase in compressive strengths, as compared to plain mortar control samples. Water/cement ratio in the range of 0.35-0.4 were found to produce the higher strengths, together with a 0.1% dosage rate for the CNT/CNF. Statistical analysis of the test results showed the significance of the enhanced strengths. It seemed that the CNT was better dispersed in the cement matrix than the CNF, because a correlation between the flow test results and the compressive strengths was detected for the CNT samples. SEM (Scanning Electron Microscope) images showed fair to good dispersion of CNT/CNF in the hardened samples.

ISSN No: - 2456 – 2165

VI. LIMITATIONS

• Geopolymer concrete is do not have immediate harden property at room temperature as in conventional concrete.

• Geopolymer concrete specimens takes a minimum no of 3days for complete setting without leaving an impression on the hardened surface.

Useful Advantages

Economical as the price of fly ash is low.

Proves better strength and durability.

Fire proof, as higher resistance to heat.

Low permeability as the pores are filled.

Eco-friendly as reduced quantity of cement is used.

Magnificent properties with both acid and salt exposed environments.

VII. CONCLUSION

From the previous research studies, it can be sequel that the reduced CO_2emissions of geopolymer concrete with Nano technology is the good alternative to the ordinary Portland cement concrete. Geopolymer concrete has excellent properties within both acid and salt environments. Higher concentration of sodium hydroxide solution results in higher compressive strength of geopolymer concrete. Low calcium fly ash based geopolymer concrete has excellent compressive strength, exposure to aggressive environment, workability, exposure to high temperature and is suitable for structural applications. Nano silica influences the strength and also the workability of geopolymer concrete to a fair level. Titanium dioxide in geopolymer concrete will be is carried over for better performance to be achieved. The experimental investigation for this research work based on the literatures were carried on to find out the exact optimization of Nano technology in geopolymer concrete, to pave way for sustainable construction.

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