A REVIEW BASED ON DEVELOPMENT OF FLY ASH BASED GEOPOLYMER BINDER ACTIVATED IN PRESENCE OF SEWAGE SLUDGE.

Darsana Sahoo[1] , Dr. Suman Pandey[2]

[1]*M. Tech student, Department of civil Engineering, Techno India University, Kolkata, India*
[2]*Assistant professor, Department of civil Engineering, Techno India University, Kolkata, India*

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Abstract- *The outcome of wastes has been increased many folds now a days and its disposition is a great challenge. Again, one tone cement produces one tone carbon-dioxide. There is scarcity of lime stone also. Perfect utilization of the waste materials in a way to develop alternative of cement binder is very much needed. Though, minimum use of waste materials i.e., slag, fly ash etc. is made in cement manufacturing unit as blender and road construction as filler materials. Again, this waste material may enhance the possibility of ground water contamination problem due to the leaching of toxic and heavy metals, ultimately reaching to underground water reservoir. Recently it is observed that geopolymer can be developed from the waste materials (like fly ash, slag) comprising silica and alumina, in an alkaline environment (usually commercial hydroxide and silicate). This research aims to investigate the effect of incorporation of sewage sludge as an activator in the formation of fly ash based geopolymer. The objective of the present research is to develop fly ash based geopolymer by using sewage sludge (pH>8.0) as primary activator. The use of commercial sodium silicate may be replaced by highly reactive alkaline sludge which is readily available as municipal waste.*

Key Words- **Geopolymer, fly ash, sewage sludge, sodium silicate**

1. INTRODUCTION

The results of wastes have been increased many folds now a days and its disposition is a great challenge. Again, one tone cement produces one tone carbon-dioxide. Perfect use of the waste materials in a way to develop alternative of cement binder is very much needed. Joseph Davidovits introduced geopolymer as an alternative of cement binder which can be made from the alkali activation of source materials comprising silicon and aluminum. Recently it is observed that geopolymer can be developed from the waste materials (like fly ash, slag) comprising silica and alumina, in an alkaline environment (usually commercial hydroxide and silicate).

1.1Background of geopolymer?

Geopolymers have caught the attention of many environmentalists and material scientist replacement for ordinary Portland cement (OPC) to reduce the emissions of greenhouse gases which is the main contributor to global warming (Huntzinger and Eatmon, 2009) and can be used as an alternative to cement concrete which will eventually cause less health hazard and pollution (Feely et al.,2004) studies of Geo polymer concrete has proven and that it has remarkable advantage over conventional cement concrete in terms of durability and also sustainability (Mehta and Burrows, 2001; Castel and Foster, 2015; Ganesan et al., 2014).

1.2Chemistry of geopolymerisation

Geopolymers are related to aluminium silicate structures in which the role of charge balancers is played by alkaline cations. Geopolymers have amorphous structure, different from zeolites which are crystalline. The pozzolanic reactions of geopolymerisation involving silica and alumina in alkaline solution can be described as following: **1. *dissolution at the surface of Al and Si in highly alkaline solution;2. diffusion of the species through the solution; 3. polycondensation of Al and Si complexes with the added silicate solution;4. and formation and hardening of a gel to form the final geopolymer***. Geopolymers can be formed by the polymerization of individual silicate and aluminate species that are dissolved from their sources at low pH in the presence of external calcium sources, and then it is undergone heat curing.

1.3Fly Ash

Fly ash is the finely divided leftover that is the outcome of the combustion of pulverized coal and is transported from the combustion chamber by exhaust gases.

1.3.1Where is fly ash used?

20 million metric tons (22 million tons) of fly ash are being used in a variety of engineering applications in a year. Highway engineering applications include (1). portland cement concrete (PCC), (2) soil, (3) asphalt filler, (4) grouts and road base stabilization, (5) flowable fills.

1.3.2Environmental benefits.

Use of fly ash especially in concrete has made a significant environmental benefit which includes (1) increasing the life of concrete roads and structure (2) improvement of the concrete durability (3) reduction in energy use (4) reduction in greenhouse gases and other harmful air emissions (5) saving of other natural resources and materials.

1.4Classification of Fly Ashes

The American Society for Testing and Materials (ASTM) C618 has defined two types of fly ashes: Class F and Class C. The main difference between these classes is the amount of calcium, alumina, silica and iron content in the ash. The chemical properties of fly ash are determined by the chemical content of the coal burned.

On the basis of application, it is not necessary for all the Fly Ashes to meet the ASTM C618 requirements. Fly Ash which are used as cement replacement must meet strict construction standards.75% of fly ash must have fineness of 45 µm or less and the carbon content as measured by the loss on ignition (LOI) should be less than 4%. In the US, LOI must be under 6%.

1.4.1Class F Fly Ash

When hard old anthracite and bituminous coal is burned it produces Class F fly ash. This ash is pozzolanic by nature and it contains7% lime (CaO) it possesses pozzolanic properties the glassy silica and alumina

Class F fly ash requires a cementing agent like quicklime, Portland cement which is mixed with water to react and form cementitious compounds. On adding chemical activator such as sodium silicate (Water glass) to Class F fly ash it can form a geopolymer.

1.4.2Class C Fly Ash

On burning of younger lignite or sub bituminous coal the Fly ash which is produced is known as Class C Fly Ash. It has self-cementing properties as well as pozzolanic properties. In the presence of water Class C fly ash hardens and gets stronger with time. It does not require any activator because it has self- cementing properties unlike Class F Fly ash and also the content of sulphate is generally high in this type of fly ash. It also contains more than 20% of lime (CaO).

1.5Sewage Sludge

Sewage sludge is produced as a by-product during sewage treatment of industrial or municipal wastewater. It is the residual, semisolid material. The term "septage" refers to sludge from simple wastewater treatment but is connected to simple on-site sanitation systems, like the septic tanks.

Approximately 50% of the suspended solid matter will settle out in an hour and a half when fresh sewage or waste water enters primary settling tank. This process is known as raw sludge or primary solids and is "fresh" before anaerobic processes become active.

1.6Sodium silicate

Sodium silicate is the common name for a mixture of compounds, mainly the metasilicate, better called **liquid glass, water glass.** The product has a huge variety of uses, which includes the formulation of cements, passive fire protection, textile and lumber processing, manufacture of refractory ceramics, as adhesives, and in the production of silica gel.

2.LITERATURE REVIEW

Xu H. et.al. (2000) anticipated that the chemical properties of geopolymer are similar to that of the zeolites. But these particles possess a complete amorphous characteristic. As per author mutual polymerization of the species of alumina and silicate was formed by this process. This product was actually originated by dissolving source material comprising of silicon and aluminium high value of pH. It only occurred with the presence of alkali silicate solvent. The research includes the investigation on geopolymerisation from fifteen natural Al-Si minerals in a way to govern the consequence of mineral characteristics on the strength of developed geopolymer. Again, the research output defines maximum dissolution of alkali solution for framework silicates in compare to chain, sheet and ring structures. The author suggests KOH instead of NaOH in maximum cases out of the fifteen minerals. The research appropriately correlates the ion pair mechanism with the mineral dissolution as well as the geopolymerisation. The research on the other hand, exhibited the several source of materials which can be potentially used in the purpose of geo-synthesis.

J G S Jaarsveld. et.al. (2003) suggested in this research work that not every waste material is dissolved in alkali solution. Because of that the author mentioned that original structure of some waste particles remains intact and contribute to either quicken or toughen those developed frameworks.

Author recognized the degree of crystallinity of the geopolymer is the prime influencing parameter for strength perspective. Again, the presence of calcium in fly ash and its role towards strength development has been found out. The extent of particle, calcium contamination, metals in alkaline medium and base material category directly influence initial synthesis and the final product.

Khale D. et.al. (2007) addressed geopolymerisation as a broad scope of research for utilizing solid waste products. Khale D. et.al briefly elaborated various factors which influence the mechanism of geopolymerisation and development of geopolymer. The impact of various parameters like starting materials, alkali activators, super-plasticizers, curing temperature, curing time, Silicate-Hydroxide ratio, alkali concentration, Silicate Aluminium ratio, liquid- solid ratio has been briefly described. Again, the author has focused on few important terms in connection with geopolymerisation like calcination, relative humidity. Immobilization of toxic metal by geopolymer along with micro-structural characterization are worked out in this research. The author depicted geopolymerisation as embryonic tool for the operation of several waste disposals.

J Temuujin. et.al. (2009) introduced the power driven or mechanical activation of ash and its impact on the features of the geopolymers developed at ambient heat exposure. Essentially this process influenced by grain size and morphological stand point. The author indicates towards the fact that the harden property of polymeric compound were reduced along with the introduction of free water in the reaction mix. For raw and routinely activated samples, strength under room temperature curing was found 16 (2) MPa and 45 (8) MPa, respectively. This procedure was performed in a typical methodology where milling agent to powder ratio was controlled as 10:1. This activation was proved efficient to improve the size and shape of the grains in connection with better reactive potentiality without allowing major alteration in mineral arrangement. Around 80% increment was observed for the fly ash activated by this technology rather than ordinary one. The key role to increase the strength of polymeric product was endorsed through this methodology by minimizing the grain size and modifying the morphological extent. There by this methodology directly emphasize the higher rate of suspension or reactivity by tuning the size of grains or particles through mechanical process of activation.

Zuhua Z. et.al. (2009) executed a program on the role of water as a key parameter in formation of calcined kaolin based geopolymer. It was observed in X-ray diffraction (XRD) and thermo-gravimetry (TG) that the activity growth of calcined kaolin was decreased by the residual water prior to the formation of stable crystalline phases. Reaction heat evolution capacity showed that high liquid/solid ratio may increase the rate of dissolution of raw materials and the hydrolysis of Si 4 + and Al 3 + compounds. The author suggests that the effect of non-evaporable water is a key parameter in connection with the strength variation of geopolymers. In this study the results point out that non- evaporable water is indispensable to maintain the strength stable and the optimum content was about 7.4%. In kaolin calcination, remaining water ebbed the activity growth of calcined product before the formation of the stabled crystalline phases. The higher liquid is to solid ratio could increase the percentage of dissolution and hydrolysis, if OH − concentration was high enough, but it might hinder polycondensation process. Geopolymers exhibited large shrinkage property while cured in air unlike in a little expanded hydrothermal condition. Finally, to conclude that for the upcoming application of this new material, the environmental condition, such as humidity and temperature should be taken into count.

Prud'homme. et.al. (2010) stated that the synthesis of geopolymers on the basis of alkaline polysialate was achieved at low temperature (25–80 0 C), by the alkaline activation of raw minerals and silica fume. Dehydroxylated kaolinite and alkaline hydroxide pellets solution (Dissolved in potassium silicate) was used to prepare the materials. After that, the constituents were transmitted to a polyethylene mould sealed with a top. Then the materials were employed to oven at 70 0 C for 24 hours. FTIR-ATR spectroscopy studied that a polycondensation reaction was used in the formation of the amorphous solid for all geopolymer materials following dissolution of the raw materials. It was occurred since the thermal measurement having a 0.22 W m −1 K −1 value. Again, TGA-MS experiments confirmed that there was a synthesisation of in situ inorganic foam based on silica fume from the in situ gaseous production of dihydrogen owing to the oxidation of free silicon (content in the silica fume) by water in alkaline medium. For the applications in building materials, this substance had potentiality as an insulating material.

Abdul Aleem (2012) Geopolymer has high early strength so it can be used in precast industries so that huge production can be made in short duration of time and breakage during transportation can also be minimized. Geopolymer can also be used in infrastructure works. Moreover, fly ash can be used effectively so no landfills are required to dump Fly Ashes.

Joseph Davidovits (2013) Stated in his research that the existing Portland cement standards are not used to geopolymer cements. Presence of standard geopolymer cements is required. Although all experts have produced their own recipe depending upon the local raw materials (wastes, by products or extracted). There is a necessity to select a Standard geopolymer cement category.

According to 2012 State of Geopolymer suggested to select two categories

- Type 2 fly ash based geopolymer cement: fly ashes are available in major emerging countries.
- Ferro sialate based geopolymer cement: this is rich in iron and is present all around the globe
- The appropriate user-friendly Geo polymeric reagent.

Kefiyalew Zerfu and Januarti Jaya Ekaputri (2019), stated that fly ash based geopolymer had been used in high strength concrete applications in dame tunnel and high-rise buildings. Fly Ash based concrete can also be used in construction of airport pavements. High load pressure due to high tire pressure during summer deform the surface of the pavement. Since geopolymer has got high tensile and compressive strength it will avoid such damages to occur. Therefore, geopolymer is suggested to use for airport pavement construction because of its high strength to resist static load from aircraft. Geopolymer is also a good choice for storage of radioactive and toxic wastes.

3. CONCLUSION

The function of sodium silicate is to initiate the polymerization basically at an early stage of reaction. The degree of aluminosilicate polymerization depends on the presence of silicate solution as the source of reactive silica [E Obonyo et al.,2011]. As metal hydroxide interacts with the reactive solid material in presence of silicate solution, its states the generation of silicate and aluminate monomers in the mixture.

The major drawback is that this silicate solution consists more than 65% of water which is responsible for porous character and semi crystalline phases in geopolymer. Earlier research [C. Kuenzel et al.,2012] accused the excessive structural water; as the prime cause of drying shrinkage in with aging and successive generation of crack with time. The scope of using alkaline sludge as an alternative of sodium silicate maybe investigated.

The objective of the present research is to develop fly ash based geopolymer by using sewage sludge. The use of commercial sodium silicate may be replaced by highly reactive alkaline sludge which is readily available. The experimental investigation is aimed to develop a new trend of economic fly ash based geopolymer with the betterment in micro and macro level.

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