Saviour, the Future Concrete: A Research

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Abstract— Sustainable development. As India is a fastest growing country in the world. Therefore developing nation the prime requirement is the infrastructure for the industries and offices. Geopolymer concrete is such a one and in the present study, to produce the geo-polymer concrete the Portland cement is fully replaced with fly ash and the fine aggregate is replaced with quarry dust and alkaline liquids are used for the binding of materials. The alkaline liquids used in this study for the polymerization are the solutions of Sodium hydroxide (NaOH) and sodium silicate (Na2Sio3). Different molarities of sodium hydroxide solution i.e. 8M, 10M and 12M are taken to prepare different mixes. The compressive strength is calculated for each of the mix. The cube specimens are taken of size 150mm x 150mm x 150mm. The Geopolymer concrete specimens are tested for their compressive strength at the age of 7days.Mix proportion of M20 grade i.e 1:1.5:3 and w/c of 0.46 was selected and 30% of mix proportion of concrete gives maximum strength than natural aggregate concrete i.e 19.8 N/mm2 on 28 days.

Keywords: Fly Ash, GGBS, Fully replacement of Cement, minimum water requirement, etc.

I. INTRODUCTION

Geopolymer concrete made up of fly ash, bottom ash, coarse aggregate, fine sand, and an alkaline solution of potassium hydroxide and potassium silicate can play a vital role in its environmental control of CO2 emissions. Steel reinforcement which is used in concrete structures has both advantages and disadvantages. It has a high compressive strength compared to other building materials; but also reduces the durability and longevity of concrete, due to its proneness to corrosion. The durability of concrete has a direct impact on its service behaviour, design life, and safety. There are several factors that are responsible for degradation/deterioration in reinforced concrete structures. One of the factors responsible for the degradation is the corrosion of steel. The corrosion of steel reinforcement is complex. In simple words, it is similar to the electrochemical reaction of a battery. There are two stages of steel corrosion in concrete. In the first stage, the elements such as carbon dioxide or chloride present in the surrounding medium penetrate in concrete. In the second stage, these elements are in high concentration at the reinforcement level, resulting in rust growth, which can cause concrete cracking [1]. There are many techniques available for the prevention of corrosion in reinforced concrete structures. An Epoxy coating can prevent the formation of corrosion but can affect the rebar and concrete interface. Stainless steel reinforcement can also help to prevent the rust reaction, but cost is an issue. The cost of repairs can be minimized by delaying the corrosion cracking process.

A. *Scenario of GEO-POLYMER Concrete:*

Geopolymer concrete cylinders and beams were made to test the strength and corrosion durability and OPC cylinders and beams were made to test and compare the properties with GPC. In the beginning stage, cylinders were experimented to find the compressive strength to know about the properties of GPC at different ages. In the later stage, beams were experimented to study about the accelerated corrosion testing of centrally reinforced beams to find out the cracking behaviour of GPC after corrosion of the reinforcement. In the final step, the beams were tested for the residual flexural strength of GPC and also to determine the mass loss of the reinforced steel.

II. SIGNIFICANCE OF STUDY

Our aim is to have an alternative binder instead of Cement in Concrete. Thus this concrete has Chloride permeability rating of low to very low as per ASTM ; better protection to R.F. Steel. Reduce the stock of wastes. Reduce the carbon emission by reducing Portland cement demand. Produces more durable infrastructure capable of design life measured in hundred of years.

III. LITERATURE REVIEW

1) Geopolymer Chemistry
2) The concept of “GEOPOLYMER” was first proposed by Davidovits in the late 1970’s [2]. He proposed that geopolymer is an alkaline liquid that could react with the aluminum (Al) and the silicon (Si) in a source or by-product materials such as fly ash to produce binders. In this case, the chemical reaction that takes place is known as polymerization process. Geopolymers are chains or networks of mineral molecules connected with covalent bonds. Davidovits suggested a word poly(sialate) to describe the chemical designation of geopolymers based on silico-aluminates. The term sialate is an abbreviation of silicon-oxo-aluminate. Poly(sialates) possess this empirical formula: Mn{-(SiO2)z-AlO2}n, wH2O Where M = cation or the alkanine element such as potassium, calcium or sodium; n is a dergree of polymerisation or polycondensation; the symbol – indicates the presence of a bond; z is 1,2,3, upto 32
3) There are three types of silico-aluminate structures from polymerization reaction (Davidovits 1991),
4) The following two stages chemical reactions represent the development of the geopolymer developed by davidovits and are accepted widely:
5) Geopolymerization is a complicated process responsible for the formation of geopolymer. Geopolymer is formed when the alumino-silicate oxides (Si2O5, Al2O2) chemically react with alkali polysilicates producing polymeric Si – O – Al – O bonds. Polysilicates are

generally fine silica powder produced as a by-product of Ferro-silicon metallurgy or potassium or sodium silicate supplied by chemical Industries [3]. In the last reaction, we can see that water is released during the chemical reaction that occurs during the formation of geopolymers. Therefore, water plays no role in the chemical reaction. This is in contrast to the Portland cement concrete mixing during hydration process. The general mechanism for alkali activation of alumino-silicates has been modeled by Gluhhovsky by dividing the process into three stages: 1) destruction-coagulation; 2) coagulation-condensation; 3) condensation-crystallization [4]. Different authors have elaborated the Gluhhovsky theory and applied the knowledge about zeolite synthesis to explain the geopolymerization processs. Figure 1 shows a simple reaction mechanism for geopolymerization.

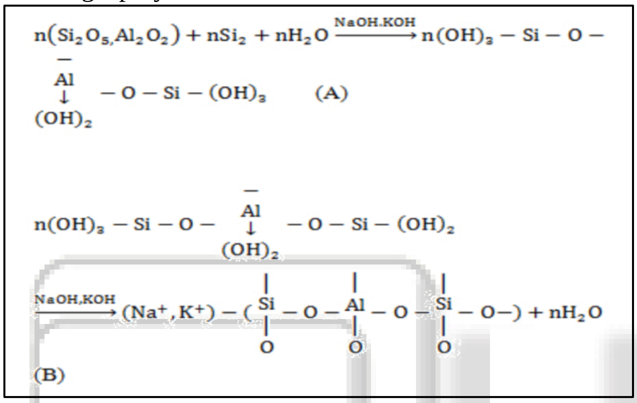


Fig. 1: Conceptual model of Geopolymerization

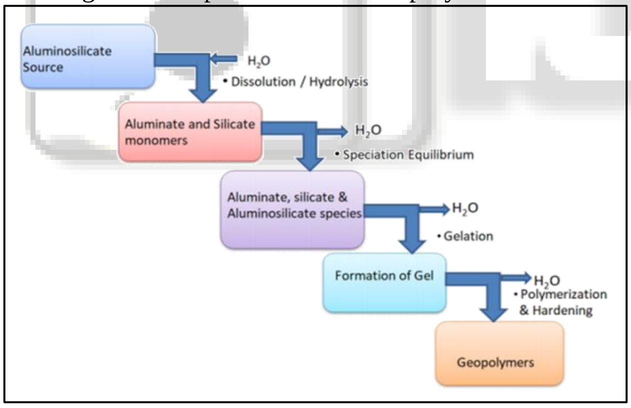


Fig. 1: Conceptual model of Geo-Polymerisation.

IV. Material Used

A. Fly-ASH:

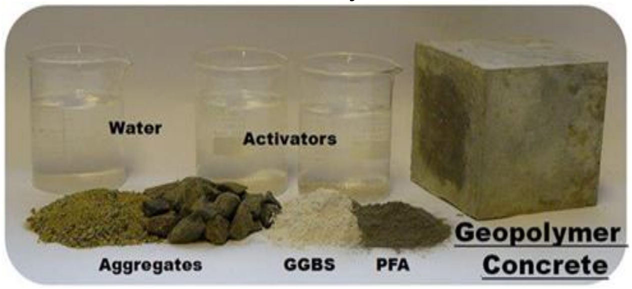
Fly-Ash can be used as prime material in many cement-based products, such as poured concrete, concrete block, and brick. One of the most common uses of fly-ash is in Portland cement concrete pavement or PCC pavement.

B. GGBS:

Ground-granulated blast-furnace slag is obtained by quenching molten iron slag from a blast furnace in water or steam, to produce a glassy, granular product a glassy, granular product that is then dried and ground into a fine powder.

C. Super-plasticizers (SP'):

These are known as high range water reducers, are additives used in making high strength concrete. Plasticizers are chemical compounds that enable the production of concrete with ca. 15% less water content by 30% or more.



D. NaOH &Na2SiO3 Solution:

NaOH and Na2SiO3 are commonly used to activate the fly ash in Geo-polymer Concrete. Previous studies have shown that the Na2SiO3/NaOH ratio and NaOH molarity affects the compressive strength of the geopolymer mortar.

E. Quarry Dust:

Quarry dust is a by-product of the crushing process which is a concentrated material to use as aggregates for concreting purpose, especially as fine aggregates. In Quarrying activities, the rock has bzeen crushed into various sizes; during the process, the dust generated.

V. Feasibility Study

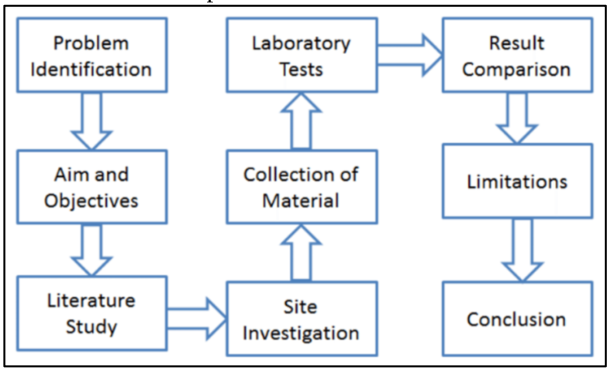
A. Fly Ash-Based Geopolymer Concrete

In this work, fly ash- based geopolymer is used as binder as hydraulic cement, instead of Portland or cement paste, to produce concrete. The fly ash based geopolymer paste binds the loose coarse aggregates, fine aggregate sand and other un-reacted materials together to form the geopolymer concrete, with or without the presence of admixtures. The manufacture of geopolymer concrete is carried out using the usual concrete technology methods .As in the case of OPC concrete, the aggregates occupy about 75-80 % by mass, in geopolymer concrete. The silicon and the aluminium in the fly ash react with an alkaline liquid that is a combination of sodium silicate and sodium hydroxide solutions to form the geopolymer paste that binds the aggregates and other un-reacted materials.

B. Properties and Application of Geopolymer Concrete

Molecules of granite are highly packed and impervious can be used after breaking into angular pieces.

GEOPOLYMERS posses high early strength, low resistance, frzee and thawing resistance, resistance to sulphate, corrosion resistance, acid resistance, fire resistance, and no dangerous alkali-aggregate reaction. Based on laboratory tests, geopolymer concrete can harden rapidly at room temperature and gain the compressive strength in the range of 20 MPa after only 4 hours at 20ºC and about 70-100 MPa after 28 days. Geopolymer mortars and reported that most of the 28- day strength was gained during the first 2 days of curing. Geopolymeric concrete was superior to Portland cement in terms of heat and fire resistance, as the Portland cement experienced a rapid deterioration in compressive strength at 300°C, whereas the geopolymeric concrete were stable up to 600°C .It has also been shown that compared to Portland.



Performing methodology as mentioned in fig,

APPLICATION

Table: 1
Various Applications

Si:Al ratio	Applications
1	Bricks Ceramics Fire protection
2	Low CO_2 cements and concretes Radioactive and toxic waste encapsulation
3	Fire protection fiber glass composite Foundry equipments Heat resistant composites, 200°C to 1000°C Tooling for the aeronautics titanium process
>3	Sealants for industry, 200°C to 600°C Tooling for the aeronautics SPF aluminium
20-35	Fire resistant and heat resistant fiber composites

cement, geopolymeric concrete has extremely low shrinkage. The presence of alkalis in the normal Portland cement or concrete could generate dangerous. Alkali-Aggregate-Reaction. However the geopolymeric system is safe from that phenomenon even with higher alkali content. Geopolymer concrete is also acid-resistant, because unlike the Portland cement, geopolymer concrete does not rely on lime and are not dissolved by acidic solutions.

VI. Methodology

With an objective to identify the manufacturer of geopolymer concrete block above methodology is adopted. output regarding various aspects was obtained and are mentioned in subsequent subsections.

A. Fix the alkaline activator solution (AAS) content -

In the mix proportioning of normal concrete, water content is and the same procedure can be adopted in case of GPC also for content in the mix can be kept within the maximum water content limit.

fixed based on the maximum size of the aggregate (IS 10262: 2009), and the same procedure can be adopted in the case of GPC also for fixing the AAS content. By following this method, the total water content in the mix can be kept within the maximum water conten

B. Selection of alkaline activator solution to fly ash ratio (AAS/FA) (or) determination of strength –

Generally when strength is considered as the principal criteria then the alkaline activator solution to fly ash ratio corresponding to the 28 day compressive strength can be chosen by adopting the standard water to cement ratio curve of normal concrete.

C. Calculation of binder content –

Fly ash content was calculated using AAS/FA ratio and AAS content. Let Bc be the binder content,then
Binder content Bc = AAS content/AAS/FA

VII. Advantages

1) High Strength – it has a high compressive strength that showed higher compressive strength than that of ordinary concrete. It also has rapid strength gain and cures very quickly, making it an excellent option for quick builds. Geopolymer concrete has high tensile strength. It is less brittle than Portland concrete and can withstand more movement. It is not completely earthquake proof, but does withstand the earth moving better than traditional concrete..
2) The creep of geopolymer concrete is very low. When speaking of creep in concrete terms it means the tendency of the concrete to become permanently deformed due to the constant forces being applied against it.
3) Resistant to Heat and Cold – It has the ability to stay stable even at temperatures of more than 2200 degrees Fahrenheit. Excessive heat can reduce the stability of concrete causing it to spall or have layers break off. Geopolymer concrete does not experience spalling unless it reaches over 2200 degrees Fahrenheit. As for cold temperatures, it is resistant to freezing. The pores are very small but water can still enter cured concrete. When temperatures dip to below freezing that water freezes and then expands this will cause cracks to form. Geopolymer concrete will not freeze.
4) Chemical Resistance – it has a very strong chemical resistance. Acids, toxic waste and salt water will not have an effect on geopolymer concrete. Corrosion is not likely to occur with this concrete as it is with traditional Portland concrete

VIII. Conclusion

The primary aim of this project was to experimentally study the corrosion resistance of bottom ash and fly ash based reinforced geopolymer concrete, compared to Ordinary Portland Cement concrete. By analyzing the test results, the following conclusions can be drawn.

– The average compressive strength of fly ash based geopolymer concrete is similar to OPC concrete which makes it suitable for structural applications. The average strengths of GPC cylinders at 7 days and 28 days were 26.65 MPa and 31.70 MPa respectively. For the OPC, the strengths were 26.93 MPa and 33.67 MPa respectively. It can be concluded from the results that both GPC and OPC cylinders cured after 28 days are stronger than those were only cured for 7 days.
– After nearly 200 hours of accelerated corrosion test, a crack was observed in the OPC beams. On the other hand, there were no cracks observed in the GPC beams. This makes it clear that GPC beams are highly durable than OPC beams.

- The Half-Cell Potential values decreased for both the specimens during the test period. The trend line of both GPC and OPC specimens is in a decline manner, which indicatesan increase in the probability of corrosion from Day 1 to Day 13. After day 13, both the specimens showed 90% probability of corrosion.
- The corrosion rate of the geopolymer concrete specimens is in between 10 µm/year and 20 µm/year. This indicates that these specimens have moderate to high rate of corrosion. Whereas, the corrosion rate of the OPC specimens is 40 µm/year and 60 µm/year, which indicates very high rate of corrosion. This proves the geopolymer concrete posses better results for corrosion rate compared to ordinary Portland concrete and hence the geopolymer concrete can be utilized in marine environment.
- The loading capacity of the OPC beams is less as compared to the GPC beams.
- The percentage mass loss for the GPC beams were 3.13%, 4.13% and 5.16% respectively, whereas, for the OPC beams it is 21.80%, 16.73% and 19.52% respectively. The OPC beams showed huge mass loss due to the crack formation which makes the chloride ions to penetrate quickly into the concrete and increase the rate of corrosion.
- The studies have shown that the performance of geopolymer concrete specimens is comparable to that of OPC concrete with respects to reinforced corrosion.

This research has shown a few properties of geopolymer materials to enable its use as a building material. The geopolymer materials possess a higher resistance to the corrosive activity of salt solutions compared to OPC. This makes a possibility to use geopolymer in industrial pipelines and marine environments. All the results look very promising, but require broader study to make sure its requirement.

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