Observation on Quality & Quantity of Aggregate Content in Concrete Mix Design by Adding Fly Ash Based Geopolymer

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Abstract— This Research paper work proposes application and better implementation of artificial immune system approach so that it enables to develop an algorithm for optimizing multi-objective problems. The main objective of this research is to analyze and enhance the artificial immune system approach for developing an algorithm to solve various real life based engineering multi-objective optimizing problems. This algorithm will be used to optimize multi objective problems. The main idea of algorithm is adopted and derived from the biological system of immune. The focus for choosing the artificial immune system to develop algorithm was, if an adaptive pool of antibodies can produce intelligent behavior, then we can use this power of computation to point out the problems. This artificial immune system algorithm makes use of mechanism of vertebrate immune system along with clonal selection principle. This model presents crossover mechanism which is integrated into traditional immune system algorithm based on clonal theory. The Algorithm is proposed with the value of real parameters in spite of binary coded parameters. Only non-dominated individual and best feasible antibodies will added. All the individuals in memory set will be cloned. In this work a novel artificial immune system algorithm is proposed. The proposed algorithm is then further implemented to solve real life engineering multi objective optimizing problems. Not only one solution, but, preferred multi sets of solutions near the reference point are found. We can minimize and maximize complex multi objective optimizing problems where both the objectives can best meet and none of the objective can bypass other objective. This algorithm will guide search for the global Pareto optimal front and maintains the solution diversity. Biological Info-system basically classified into the systems like Endocrine System, Nervous System, Genetic System, and Immune System. Biological Info-processing-systems have further many more interesting functions and are also expected to give various feasible ideas for engineering fields, Industrial Control Systems, Pattern recognition, Information encryption, Robotics, Network security, Intrusion detection and further more. Artificial Immune System is a type of system which is developed on the basis of the current understanding of the immune system. It is also consists of various properties like diversity, distributed computation, self-monitoring, cache coherence, dynamic learning and error tolerance. In fact the Artificial Immune System is inspired by immunology, immune functions, observed many biological principles and their models, which may applied for complex problems.

Keywords: Fly Ash, Geopolymer

I. INTRODUCTION

The development of infrastructure, industry and housing is necessary. Without concrete, the built environment would fail to accommodate our modern and demanding lifestyles. Given our reliance on concrete, it will inevitably play a major role to pursue sustainable development in any country. At its most basic, concrete is a mixture of aggregates, cement, sand and water. Portland cement is the generic term for the type of cement used in virtually all concrete. Cement comprises from 10 to 15% of the concrete mix, by volume. Through a process called hydration, the cement and water harden and bind the aggregates into a rock-like mass. With appropriate mix design, concrete can be tailored for any construction requirement.

Understanding the role of aggregates in concrete is fundamental to the production of good concrete as aggregates have their greatest influence on the performance of fresh concrete (Alexander and Mindess, 2010).

The aggregates form 60 to 80 per cent of the volume of concrete. Despite the amount of aggregates used in production of concrete, their influence is sometimes overlooked and the aggregates are considered only as fillers. However, it is essential to consider and study all of constitutes in concrete mixtures, including aggregates, in order to obtain a comprehensive understanding of the behaviour of the final product. As a result of such considerations, it is clear that the role of aggregates is crucial to ensure satisfactory performance of mixtures since they govern the volumetric stability of concrete.

In addition, aggregates have an important effect on concrete strength by providing rigidity to the material which governs resistance to applied loads and undesired deformations.

The original w/c ratio law for concrete strength introduced by Abram (1918) was limited to normal structural concrete with maximum aggregate size of 38 mm and w/c ratio greater than 0.4.

II. FUNDAMENTAL CONCEPTS

The Global use of concrete is second only to water as the demand of concrete as a construction material increases so also a demand of Portland cement. It is estimated that the production of cement has been increased from about 2.2 million tons in 2010 to 3.5 million tons in 2016. By 2025, cement production will reach to 550 million tonnes (Business Standard, Ministry of External Affairs, TechSci Research, Ministry of External Affairs).

Concrete has an excellent structural performance and durability, but is affected by early deterioration when subjected to a marine environment. On the other hand the climate change due to global warming has become a major concern. Because of production of 1 tones of Portland cement emits approximately 0.8 tones of CO_2 into the atmosphere (Davidovits,1994'McCaffrey,2002). The cement industry is held responsible for some of the carbon dioxide emission. In

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this respect the geopolymer technology shows considerable promise for application in concrete industry as an alternative binder to the Portland cement. In terms of global warming the geopolymer technology significantly reduce the carbon dioxide emission to the atmosphere caused by the cement industry.

III. Objectives of Research

Concentrating on compressive strength of concrete alone is one of the main reasons for deterioration of concrete in the past. As a result, strength enhancement of concrete gained more importance to the advancement in concrete technology. It is now well established that strength of concrete, which is exposed over its entire life, alone is not sufficient to resist the effect of harsh environmental condition.

The aim of the study is to assess the effect of use of fly ash in concrete as compare to cement concrete elements in marine condition of.

- To compare the compressive strength of concrete by replacing 100% percentage of cement by fly ash with conventional concrete at constant molarity , as well as to study, the effect of varying curing time period under normal condition.
- Compare the durability behaviour of GPC (Geopolymer Concrete) & Conventional Concrete (CC) under chloride solution.
- Compare the durability behaviour of Geopolymer Concrete & Conventional Concrete under sulphate solution.

IV. Literature Review

In 1978, Davidovits proposed that a binder could be produced by a polymerisation process involving a reaction between alkaline liquids and compounds containing aluminium and silicon. The binders created were termed "geopolymers". Unlike ordinary portland/pozzolanic cements, geopolymers do not form calcium-silicate-hydrates (CSHs) for matrix formation and strength, but silica and alumina reacting with an alkaline solution produce an aluminosilicate gel that binds the aggregates and provides the strength of concrete. Source materials and alkaline liquids are the two main constituents of geopolymers, the strengths of which depend on the nature of the materials and the types of liquids.

Materials containing silicon (Si) and aluminium (Al) in amorphous form, which come from natural minerals or by-product materials, could be used as source materials for geopolymers. Kaolinite, clays, etc., are included in the natural minerals group whereas fly ash, silica fume, slag, rice-husk ash, red mud, etc., are by-product materials. For the manufacture of geopolymers, the choice of source materials depends mainly on their availability and cost, the type of application and the specific demand of the users (Lloyd and Rangan 2010). Fly ash-based geopolymer concretes provide excellent engineering properties that make them suitable materials for structural applications (Rangan et al. 2005; Fernández-Jiménez et al. 2006).

The type of alkaline liquid used plays an important role in the polymerisation process (Palomo et al. 1999). Sodium hydroxide (NaOH) with sodium silicate (Na_2SiO_3) and potassium hydroxide (KOH) with potassium silicate (K_2SiO_3) are the most common alkaline liquids used in geopolymerisation (Hardjito and Rangan 2005). Both sodium hydroxides and potassium hydroxide have a strong base and, at room temperature, exhibit almost identical solubilities in water. In 2005, Fernández-Jiménez and Palomo studied the effect of an alkaline liquid on the mechanical strength of fly ash-based mortar (Fernández-Jiménez and Palomo 2005). They stated that the mechanical strength of mortar increases when waterglass (Na_2SiO_3) is added to NaOH, compared with using only NaOH. The addition of waterglass increases the Si/Al and Na/Al ratios, resulting in increased formation of N-A-S-H (sodium aluminosilicate gel) which indicates greater strength. Hardjito and Rangan (Hardjito and Rangan 2005) showed that the compressive strength of fly ash-based geopolymer concrete can be improved by either increasing the concentration (in molar terms) of the sodium hydroxide solution or increasing the mass ratio of the sodium silicate to sodium hydroxide solutions. Since many reports on the destructive effect of cement production on the environment have been published (IEA 2007; Worrell et al. 2001) and, currently, fly ash-based geopolymer concrete has proven to be a suitable replacement for cement concrete due to their excellent engineering properties (Palomo et al. 1999; García-Lodeiro et al. 2007).

A. Properties of Geopolymer Concrete

1) Wallah (2009) Drying Shrinkage of Heat Cured Fly Ash Based Geopolymer Concrete used low-calcium fly ash as its source material, alkaline activators and aggregates normally used for Ordinary Portland cement concrete. Four series of test specimens with different compressive strength were prepared to study the drying shrinkage of this concrete. Results obtained were compared with the calculated results of drying shrinkage as predicted by Gilbert Method which is normally used for Ordinary Portland cement concrete. Results showed that the heat cured fly ash-based geopolymer concrete undergoes very low drying shrinkage. The drying shrinkage strain at one year as calculated using Gilbert Method was much higher, about five to seven times, compared to the measured drying shrinkage strain.
2) Olivia and Nikraz (2011) Strength and Water Penetrability of Fly Ash Geopolymer Concrete studied the strength characteristics, water absorption and water permeability of low calcium fly ash based geopolymer concrete. Mixtures with variations of water/ binder ratio, aggregate/binder ratio, aggregate grading, and alkaline/fly ash ratio were investigated. Results showed that a good quality concrete was obtained by reducing the water/binder ratio and aggregate/binder ratio; and the water absorption of low calcium fly ash geopolymer was improved by decreasing the water/binder ratio, increasing the fly ash content, and using a well-graded aggregate. No significant change was observed in water permeability coefficient for the geopolymer with different parameters.
3) Sanni and Khadiranaikar (2012) Performance of Geopolymer Concrete under Severe Environmental Conditions carried out investigation on the variation of alkaline solution on mechanical properties of geopolymer concrete. The grades preferred for the

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investigation were M30, M40, M50 and M60; the mixes were designed for 8 molar. The alkaline solution used was the combination of sodium silicate and sodium hydroxide solution with the varying ratio of 2, 2.5, 3 and 3.5. The test specimens were 150x150x150 mm cubes and 100x200 mm cylinders heat-cured at 60°C in an oven. The results revealed that the workable flow of geopolymer concrete was in the range of 85 to 145mm and was dependent on the ratio by mass of sodium hydroxide and sodium silicate solution. The freshly prepared geopolymer mixes were cohesive and their workability increased with the increase in the ratio of alkaline solution. It was concluded that the strength of geopolymer concrete can be improved by decreasing the water/binding and aggregate/binding ratios. Compressive strength and split tensile strength obtained were in the range of 20.64-60N/ mm2 and 3-4.9 N/mm2.

4) Joseph and Mathew (2012) Influence of aggregate content on the behavior of fly ash based geopolymer concrete carried out the influence of aggregate content on the engineering properties of Geopolymer concrete. Influence of other parameters such as curing temperature, period of curing, ratio of sodium silicate to sodium hydroxide, ratio of alkali to fly ash and molarities of sodium hydroxide were also discussed. Based on the study carried out, it can be concluded that a geopolymer concrete with proper proportioning of total aggregate content and ratio of fine aggregate to total aggregate, along with the optimum values of other parameters, have better engineering properties than the corresponding properties of ordinary cement concrete. Compared to ordinary cement concrete, 14.4% enhancement in modulus of elasticity and 19.2% enhancement in Poisson's ratio could be achieved in geopolymer concrete.
5) Aleem and Arumairaj (2012) A Geopolymer Review conclude that user-friendly geopolymer concrete can be used under conditions similar to those suitable for ordinary portland cement concrete. These constituents of Geopolymer Concrete shall be capable of being mixed with a relatively low-alkali activating solution and must be curable in a reasonable time under ambient conditions. The production of versatile, cost-effective geopolymer concrete can be mixed and hardened essentially like portland cement. Geopolymer Concrete shall be used in repairs and rehabilitation works. Due to the high early strength Geopolymer Concrete shall be effectively used in the precast industries, so that huge production is possible in short duration and the breakage during transportation shall also be minimized. The Geopolymer Concrete shall be effectively used for the beam column junction of a reinforced concrete structure. Geopolymer Concrete shall also be used in the Infrastructure works. In addition to that the Flyash shall be effectively used and hence no landfills are required to dump the flyash. The government can make necessary steps to extract sodium hydroxide and sodium silicate solution from the waste materials of chemical industries, so that the cost of alkaline solutions required for the geopolymer concrete shall be reduced.
6) Jaydeep and Chakravarthy (2013) Study On Fly Ash Based Geopolymer Concrete Using Admixtures prepared an optimum mix for Geopolymer concrete using admixtures. Concrete cubes of size 150×150×150mm were prepared to find out compressive strength at 7 and 28 days. Results showed that the addition of sodium silicate solution to the sodium hydroxide solution as an alkaline activator enhanced the reaction between the source material and solution. Oven cured specimen gives the higher compressive strength as compared to direct sunlight curing. It was also observed that geopolymer concrete is more advantageous, economical and ecofriendly method when compared with conventional concrete.
7) Patil, Kale and Suman (2013) A technical analysis for compressive strength investigate that Fly ash, a waste generated by thermal power plants is as such a big environmental concern. The investigation is carried out to study the utilization of fly ash in cement concrete as a partial replacement of cement as well as an additive so as to provide an environmentally consistent way of its disposal and reuse. This work is a case study for Deep Nagar thermal power plant of Jalgaon District in MS. The cement in concrete matrix is replaced from 5% to 25% by step in steps of 5%. It is observed that replacement of cement in any proportion lowers the compressive strength of concrete as well as delays its hardening. This provides an environmental friendly method of Deep Nagar fly ash disposal.
8) Ferdous, Kayali and Khennane (2013) A detailed procedure of mix design for fly ash based geopolymer concrete proposes a method for selecting the mix proportions of geopolymer concrete which may be suitable for concrete containing fly ash to be used as a cementitious material. Using a flow chart, the paper first describes the procedure in general and then illustrates it using an example. A range of mixes were made to test the method varying water-to-geopolymer solid ratio. It was found that certain basic principles established for conventional concrete still apply for geopolymer concrete mix designs. A simple graphical relationship between 28-day and 7- day compressive strengths of geopolymer concrete is also presented. A mix design method for fly ash-based geopolymer concrete has been proposed in a different approach. Variable concrete densities, the effects of the ingredients' specific gravities, contributions of air volume, flexibility to improve the workability of fresh concrete and the opportunity to use aggregates in their 'as is' condition were considered importantly for overcoming the main limitations of current design methods. Experimental results showed that the compressive strength of the fly ash-based geopolymer concrete decreased linearly with increases in the water-to-geopolymer solids ratio. This observation was in agreement with the basic principles of ordinary portland cement concrete, the strength of which decreases with increases in the water-cement ratio.
9) Aravind and Mathews, (2014) Study of Mechanical Properties of Geopolymer Concrete Reinforced with Steel Fiber carried out research on mechanical properties of Geopolymer concrete reinforced with steel fiber. This

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study focuses on the compressive strength and split tensile strength of geopolymer concrete reinforced with steel fiber. Experiments were performed using the Box–Behnken experimental design. Box–Behnken experimental design is a type of response surface methodology. Response surface methodology is an empirical optimization technique for evaluating the relationship between the experimental outputs and factors called X1, X2, and X3. For obtaining the results for Box Behnken design, analysis of variance has been calculated to analyze the accessibility of the model and was carried in Microsoft Office Excel 2007. It can be concluded that compressive strength of geopolymer concrete is gradually increased with prolonged curing period also with the increase of sodium silicate to sodium hydroxide liquid ratio by mass. Split tensile strength of geopolymer concrete increased as percentage of steel fiber increased. Another important observation was obtained that curing under normal sunlight yielded strength of 16 N/mm2

10) Shah, Parikh and Parmar, (2014) Study of Strength Parameters and durability of Fly ash based Geopolymer Concrete conducted research on strength parameters and durability of fly ash based Geopolymer concrete. In this study, two concrete mixes are to be worked out; GPC Mix-1 fly ash concrete and OPC Mix-2 Concrete mix having OPC equivalent to amount of cementitious material used in GPC Mix-1. Different parameters were used such as alkaline liquid to fly ash ratio of 0.40 ,0.45 and 0.50, ratio of NaOH to Na2 SiO3 2.0 and 2.5, molarities of NaOH; 10M ,12M, 14M and 16M. Compressive strength test, split tensile test, pull out test and durability test were performed under ambient temperature curing conditions i.e; 600 C, 900 C and 1200 C. Higher average compressive strength, tensile strength and pull out strength of 52.25, 4.10 and 10.25N/mm2 were observed for concrete GPC Mix-1 as compared to that of concrete OPC Mix-2. The test results showed that oven cured fly ash based geopolymer concrete have an excellent resistance to sulfate attack, salt attack and acid attack as compared to ambient curing. Minor increase in the mass of concrete specimens of mix has been observed due to the absorption of the sulfate, acid & salt for concrete Mix-1.

11) Junaid, Khennane and Kayali (2014) Performance of fly ash based geopolymer concrete made using non-pelletized fly ash aggregates after exposure to high temperatures studied that the superior performance of geopolymer paste, mortar and concrete (GPC) when exposed to high temperatures has been well documented. Limitations still exist however due to the use of similar aggregates, coarse and fine, in both ordinary portland cement concrete (OPC) and GPC. The behavior of geopolymer concrete at elevated temperatures can be further improved by using a recently developed lightweight non-pelletized aggregates made entirely from fly ash (named Flashag) as replacement for conventional natural aggregates. Tests for the ambient and residual properties of GPC made using these new aggregates exposed to temperatures up to 1,000 C were carried out. The obtained results in terms of compressive strength, splitting strength, and modulus of elasticity are reported and compared with those obtained for GPC produced using ordinary natural aggregates as well as with those reported in the literature for OPC concretes. The effects of heat cycling, as well as, duration of heating on the strength and deformational behavior of GPC are also investigated. At ambient temperatures all the three concretes displayed similar properties. At elevated temperatures, however, the performance of GPC made from Flashag was found to be far superior to that of both OPC, and GPC made from ordinary aggregates. Additionally, for up to 4 heating cycles, GPC made with Flashag better retained its strength and stiffness properties as compared to GPC made with ordinary natural aggregates. The study also found that most changes to the strength and microstructure of GPC occur in the first few hours of exposure after which, the duration of heating has no significant effect.

12) Gorhan, Kurklu, (2014) The influence of the NaOH solution on the properties of the fly ash-based geopolymer mortar cured at different temperatures explained that the geopolymer mortar was produced using Class F fly ash from the thermal power plant in Kutahya Seyitomer (Turkey). The changes caused by the geopolymerization on the properties of the final product were investigated by applying curing on geopolymer mortars in different NaOH concentrations at different temperatures and for different curing times. The purpose of this process was to determine the relationship between alkali solution concentration, curing temperature and curing time. In order to determine the effect of NaOH concentration on geopolymer mortars, three different molarities of NaOH concentrations (3 M, 6 M and 9 M) were used together with sodium silicate (water glass) solution. The samples were cured at two different temperatures (65 and 85 °C). Physical properties such as porosity, bulk density, apparent density and water absorption, and mechanical properties such as flexural strength and compressive strength were determined from the 7-day geopolymer mortar samples after the curing process. As a result, this study determined that curing temperature and curing time had an effect on the physical properties of the geopolymer mortars. It was observed that NaOH concentration had a clear effect on the properties of the mortar cured at 85 °C. Compressive strength values of 21.3 MPa and 22 MPa were obtained from the mortar of 6 M concentration cured at 65 °C for 24 h and from a sample of the same mortar cured at 85 °C, respectively. Compressive strength values of the geopolymer mortars cured at 85 °C increased depending on the curing time and the increase in NaOH concentration. Given the strength values obtained, the optimal thermal curing temperature and the optimal NaOH concentration were 85 °C and 6 M, respectively.

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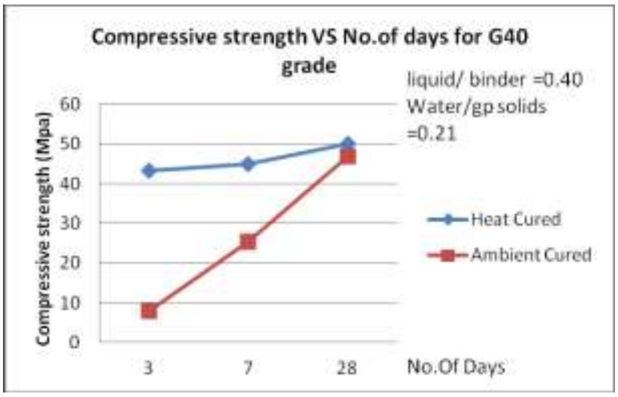

Fig. 2.1: Time-Compressive Strength Relation

13) Ramujee and Potharaju (2014) Development of Low Calcium Flyash Based Geopolymer Concrete.
    1) From the investigation he stated that for Water/binder ratio & alkaline liquid/Flyash ratio are the governing factors in designing the Geopolymer mix design for various grades. The Water/binder ratio 0.21 and Alkaline liquid to flyash ratio of 0.40 are suggested for G40 which indicates improvement in compressive strength of geopolymer concrete can be achieved by decreasing water binder ratio.
    2) The compressive strength attained at 28 days for Geopolymer concrete under ambient curing is almost equal to compressive strength achieved by Geopolymer concrete at 7 days. Because of the slow reactivity of flyash at ambient temperature, considerable heat must be applied to increase the geopolymerization process.
    3) The decrease in water content favors the formation of geopolymerization process ,which demands for increase of concentration of Sodium hydroxide and sodium silicate silicates.Hence increase in concentration of NaOH results in increase of compressive strength .Hence it is recommended 16M concentrations for medium grade.
    4) It is recommended to add Superplasticizers for high strength Geopolymer concretes, which is analogous to Conventional concrete of higher grades to secure required workability.
    5) It also reported that unlike in the past literature, inclusion of high alkaline solution content to the mix need not increases the strength which can be seen from reported Geopolym er mixes in the present work.
14) Jamdade and Kawade (2014) Evaluate the Strength of Geopolymer Concrete by Using Oven Curing.
    They give the conclusion for the strength of geopolymer concrete that:
    1) Geopolymer concrete gives more strength than Normal concrete in minimum period of curing.
    2) Higher curing temperature resulted in larger compressive strength of Geopolymer concrete, even though an increase in the curing temperature beyond 60C did not increase the compressive strength substantially.
    3) Longer curing time improved the polymerization process resulting in higher compressive strength of Geopolymer concrete.
15) Morsy, Alsayed, Al-Salloum & Almusallam (2014) Effect of Sodium Silicate to Sodium Hydroxide Ratios on Strength and Microstructure of Fly Ash Geopolymer Binder, investigates the effect of sodium silicate/sodium hydroxide ratios on the feasibility of geopolymer synResearch paper at 80 ◦C using fly ash. The sodium silicate/sodium hydroxide (S/N) ratios 0.5, 1.0, 1.5, 2.0 and 2.5 were studied. The result showed that the compressive and flexural strength increases as the curing age increases. Also, the compressive strength increases as the sodium silicate/sodium hydroxide ratio increases from 0.5 to 1.0 and then decreases. Morphology studies, conducted by SEM analysis of the geopolymer samples, indicated that geopolymers gel had the fly ash particles and pores embedded in a continuous matrix. At S/N = 1 a homogeneous and less porous microstructure was observed.
16) 2.3.16 Yasir and Iftekar (2015) Study of Properties of Fly Ash Based Geopolymer Concrete, intended to study the properties of fly ash based Geopolymer concrete. M20 grade 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 affect it are 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.
17) 2.3.17 Ramesh and Joy (2017) Review On The Study Of Fly Ash Based Geopolymer Concrete , have done experiments to find out optimum strength of concrete by replacing cement with fly ash and when it combine with alkaline solution which is known as a Geopolymer concrete. They conclude that Self Compacting Geopolymer Concrete (SCGC) is a type of concreting execution and it does not require compaction. It is made by complete elimination of ordinary Portland cement content. SCGC needs more amount of fine aggregate than coarse aggregate compared to control mix. This Geopolymer concrete technology proves to be a good alternative to cement and thus it reduces or eliminates the harmful effects caused by cement. Large emission of CO_2 can be eliminated. At the same time fly ash is a byproduct which is largely available can be effectively utilized for construction. Other factors needed to be considered are Sodium silicate to sodium hydroxide ratio or potassium silicate to potassium hydroxide ratio, Molarity of Sodium hydroxide or potassium hydroxide (according to alkali used), Alkali to binder ratio, Curing temperature and curing period.

V. METHODOLOGY

This study is design to assess the hypoResearch paper that a good binding material can be formed for the production of concrete by a polymerisation process involving a reaction between alkaline liquids and compounds containing aluminium and silicon.

Materials containing silicon (Si) and aluminium (Al) in amorphous form, which come from natural minerals or by-product materials, could be used as source materials for geopolymers. (Kaolinite, clays, etc., are included in the natural minerals group whereas fly ash, silica fume, slag, rice-husk ash, red mud, etc., are by-product materials.) In this project portland cement which is used as binding material, is 100% replaced by fly ash and various test is performed for study the behavior of the geopolymer concrete under certain condition to check whether the hypoResearch paper we made is correct or not. This project study adopted is experimentation on high performance concrete (HPC) with super plasticizer with the aim to report its suitability for concrete structure. Cement Free Green Concrete by using Fly Ash is trending now a days. The research utilized low-calcium (ASTM Class F) fly ash as the base material for making geopolymer concrete. The fly ash was obtained from only one source. Currently due to over generation of fly ash from thermal power plants, instead of dumping in landfill, researchers have found its use in making bricks. Fly ash bricks are light in weight compared to conventional bricks and have more strength. These bricks are prepared as per Indian Standard IS: 12894- 2002. It is gaining much value and several practical applications and models have also been under construction.

In today's time, this technology is being used widely in the USA, Europe and Australia. It is being used for railway sleepers, electric power poles, road pavements, cement mortar, Marine structures and Waste containments. The current trend of research is under way to develop geopolymer systems that create a low embodied energy, low carbon dioxide binder that has similar properties to Portland cement. In addition, current research is focusing on the development of user-friendly geopolymer concrete. Utilization of geopolymer concrete brings economy in construction; reduce pollution and less harmful to the environment. Thus it can be considered that geopolymer concrete, as a replacement for Portland cement has wide scope in India. An effort has been made in this project to study the advantages, application and feasibility of geopolymer concrete in India.

Ordinary Portland cement (OPC) is conventionally used as the primary binder to produce concrete. The environmental issues associated with the production of OPC are well known. The amount of the carbon dioxide released during the manufacture of OPC due to the calcination of limestone and combustion of fossil fuel is in the order of one ton for every ton of OPC produced. In addition, the extent of energy required to produce OPC is only next to steel and aluminium.

On the other hand, the abundant availability of fly ash worldwide creates opportunity to utilise this by-product of burning coal, as a substitute for OPC to manufacture concrete. When used as a partial replacement of OPC, in the presence of water and inambient temperature, fly ash reacts with the calcium hydroxide during the hydration process of OPC to form the calcium silicate hydrate (C-S-H) gel. The development and application of high volume fly ash concrete, which enabled the replacement of OPC up to 60% by mass (Malhotra 2002; Malhotra and Mehta 2002), is a significant development.

VI. Results and Conclusion

Based on the observation in the study, following conclusions can be derived:

1) A methodology for designing the geopolymer concrete has been demonstrated for implementation of ecofriendly material on large scale.
2) Proposed mix design method, targets the required compressive strength and workability.
3) The suggested method can be confidently used for alccofine and fly ash based geopolymer concrete.
4) It is possible to produce geopolymer concrete with alccofine for general purpose at room temperature (27oC).
5) By inclusion of alccofine, workable and high strength concrete can be produced which can serve the cast in situ and precast concrete industry demands.
6) Geopolymer concrete gives more strength than conventional concrete. The maximum compressive strength of the fly ash based geopolymer concrete using Alccofine at 28 days was found 70.89Mpa at 16M at heat curing and 44.65Mpa at ambient curing.
7) Compressive strength increases with the increase in molarity keeping the fly ash content and temperature constant. The minimum strength achieved was 55.29Mpa (fly ash content 400kg/cum) and maximum is 70.89MPa at 16M
8) The addition of alccofine in the fly ash mix resulted in the higher workablility and the higher strength at ambient temperature also.
9) Strength achieved is more at heat curing then at ambient curing because the geopolymer concrete attains its maximum strength in heat curing.
10) The maximum split tensile strength was found 5.6 Mpa at heat curing and 2.6 MPa at ambient curing keeping the fly ash content and the molarity constant i.e. at 16M with the fly ash content of 400kg/cum.
11) The increased compressive strength at higher temperature had been due to the properties of fly ash concrete which have better fire resistance as different hydrant products are different when compared with Portland cement concrete.
12) It is possible to produce geopolymer concrete for general purpose at room temperature (27oC).
13) Visual inspection results indicated that FAGPC specimens showed moderate surface deterioration without color change and OPC specimens exhibited greatest surface deterioration with color change from gray to white.
14) Geopolymer and OPC specimens were visually observed to remain structurally intact and maintained their initial conditions without color change, spalling and cracking when they were exposed to magnesium sulfate and sodium chloride attack.
15) Weight gain was observed for almost all specimens immersed in chemical solutions due to solution absorption and expansion occurred by gypsum

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formation. Weight gain was observed to be higher for immersed in sodium chloride solutions.

16) Although compressive strength test results after chemical exposure of the OPC specimens were slightly lower than the FAGPC specimens, loss of mechanical strengths due to chemical attack was found to be less on FAGPC specimens, which may be attributed to low calcium amount of the FAGPC specimens.
17) It can be concluded that FAGPC can be used in aggressive environments due to superior durability to chemical attack as compared to OPC.

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