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Comparative Study of Geopolymer Concrete with Conventional Concrete

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Abstract: **Globally, Cement production contributes about 1.6 billion tons of CO2 or about 7% of global loading of CO2 into the atmosphere. The manufacture of Cement releases Carbon dioxide that is significant contributor of Green house gas emissions to the atmosphere. So there was a need to develope and use eco-friendly material having similar properties as like of cement mortar. Geopolymer is produced without the presence of cement as a binder; instead, the base material such as fly ash, that is rich in Silicon (Si) and Aluminium (Al), is activated by alkaline solution to produce the binder. Hence Geopolymer mortar can be used instead of cement mortar which will have no adverse effect on our environment. Ferrocement is a composite material formed by closely spaced wire mesh which uses wire meshes as reinforcement and filled with rich cement mortar.**

GPC required high temperature for curing to happen the polymerization, Thus, the curing of GPC was done at ambient temperature without keeping it in water unlike the conventional concrete. Amongst both the alkali solutions i.e. NaOH and Na2SiO3, sodium hydroxide was used in different molar concentration of 10M, 12M and 14M with keeping silicate to hydroxide ratio constant as 1.5, three different sets of 9 cubes, 3 beams and 3 cylinders were casted.

***keywords*— Geopolymer Concrete, Fly Ash, sodium hydroxide, sodium silicate, molarity.**

I. INTRODUCTION

The rate of production of carbon dioxide released to the atmosphere during the production of Portland cement and fly ash, a by-product from thermal power stations worldwide is increasing with the increasing demand on infrastructure development, and hence needs proper attention and action to minimize the impact on the sustainability of our living environment. De-carbonation of limestone in the kiln during manufacturing of cement is responsible for the liberation of one ton of carbon dioxide to the atmosphere for each ton of Portland cement, as can be seen from the following reaction equation :

$5CaCO_3 + 2SiO_2 \; 3CaO.SiO_2 + 2 \; CaO.SiO_2 + 5 \; CO_2$ .The current contribution of green house gas emission from the Portland cement production is about 1.35 billion tons annually or about 7% of the total greenhouse gas emissions to the earth's atmosphere[1]. Furthermore, Portland cement is also among the most energy-intensive construction materials, after aluminum and steel. Geopolymer concrete is a material that does not need the presence of Portland cement as a binder. Instead, the source of materials such as fly ash, that are rich in Silicon (Si) and Aluminium (Al), are activated by alkaline liquids to produce the binder. Hence, concrete with no cement. Geopolymer is produced without the presence of Portland cement as a binder; instead, the base material such as fly ash, that is rich in Silicon (Si) and Aluminium (Al), is activated by alkaline solution to produce the binder. The Geopolymer concrete possesses high strength, undergoes very little drying shrinkage and moderately low creep, and shows excellent resistance to sulphate attack.

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 concrete significantly reduce the CO_2 emission to the atmosphere caused by the cement industries. Davidovits (1988; 1994) proposed that an alkaline liquid could be used to react with the Silicon (Si) and Aluminum (Al) in a source material of geological origin or in by product materials such as fly ash and GGBS to produce binders. Because the chemical reaction that takes place in this case is a polymerization process, he coined the term geopolymer to represent these binders.

Several efforts are in progress to address these issues. These include the utilization of supplementary cementing materials such as fly ash, silica fume, granulated blast furnace slag, rice-husk ash and metakaolin, and the development of alternative binders to Portland cement.

II. REFERENCES

"Geopolymer concrete with fly ash" by N A Lloyd and B V Rangan at Marche Polytechnic University, Ancona, Italy in June 2010.The paper presented brief details of fly ash-based geopolymer concrete. A simple method to design geopolymer concrete mixtures has been described and illustrated by an example. Geopolymer concrete has excellent properties and is well-suited to manufacture precast concrete products that are needed in rehabilitation and retrofitting of structures after a disaster. To ensure further uptake of geopolymer technology within the concrete industry, research is needed in the critical area of durability.

"GPC an eco-friendly construction material" by L. Krishnan, S. Karthikeyan, S Nathiya, K. Suganyaat IJRET: International Journal of Research in Engineering and Technology, in June 2014.The Alkaline liquids used in this study for the polymerization process are the solutions of sodium hydroxide (NaoH) and sodium silicate (Na2SiO3). A 12 Molarity solution was taken to prepare the mix. The cube compressive strength was calculated for 12M solution for different mix Id i.e.

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F90G10, F80G20, F70G30, and F60G40 (Where F and G are, respectively, Fly Ash and GGBS and the numerical value indicates the percentage of replacement of cement by fly ash and GGBS).The cube specimens are taken of size 100 mm x 100 mm x 100 mm. Ambient curing of concrete at room temperature was adopted. In total 36 cubes were cast for different mix Id and the cube specimens are tested for their compressive strength at age of 1 day, 7 days and 28 days respectively. The result shows that geopolymer concrete cubes gains strength within 24 hours without water curing at ambient temperature. Also the strength of geopolymer concrete was increased with increase in percentage of GGBS in a mix. It was observed that the mix Id F60G40 gave maximum compressive strength of 80.50 N/mm^2.

"A Review on Strength and Durability Studies on Geopolymer Concrete" by Shriram Marathe, Mithanthaya I R, N Bhavani Shankar Rao at Department of Civil Engineering, NMAMIT, Nitte, India.This paper briefly reviews the constituents of geopolymer concrete, its strength and potential applications. The production of OPC requires large amount of energy consumption, also leading to an enormous emission of carbon di-oxide to the atmosphere, which is being a great challenge to the sustainable development. Efforts are needed to develop a environmental friendly civil engineering construction material for minimizing emission of green-house gases to the atmosphere. A review summary of the extensive literature survey conducted to know about one such environmental friendly concrete namely geopolymer concrete is presented in this paper. And conclusions were as followed. The creep and shrinkage of geopolymers are substantially lower than conventional Portland concrete. Drying shrinkage strains of fly ash-based Geopolymer concretes were found to be insignificant. The ratio of creep strain to- elastic strain (called creep factor) reached a value of 0.30 in approximately 6 weeks after loading on the 7th day with a sustained stress of 40% of the compressive strength. The GPC specimens also show a higher resistance to sulphate attack after full immersion for 15 weeks in different % of magnesium sulphate solution in terms of weight loss and compressive strength as compared with conventional concrete. The performance of geopolymer materials when exposed to acid solutions was superior to ordinary Portland cement concrete.

"GPC for green environment" by B. Vijaya Rangan at The Indian Concrete Journal in April 2014.The paper describes the results of the tests conducted on large-scale reinforced geopolymer concrete members and illustrates the application of the Geopolymer concrete in the construction industry. Some recent applications in the precast construction and the economic merits are also included. Extensive studies conducted on fly ash-based geopolymer concrete are presented. Salient factors that influence the properties of the geopolymer concrete in the fresh and hardened states are identified. Test data of various short-term and long-term properties of the geopolymer concrete are then presented.

Geopolymer concrete offers environmental protection by means of up cycling low-calcium fly ash and blast furnace slag, waste/by-products from the industries, into a high value construction material needed for infrastructure developments. The paper presented information on fly ash-based geopolymer concrete. Low-calcium fly ash (ASTM Class F) is used as the source material, instead of the Portland cement, to make concrete.Geopolymer concrete has excellent compressive strength and is suitable for structural applications. The salient factors that influence the properties of the fresh concrete and the hardened concrete have been identified. Simple guidelines for the design of mixture proportions are included.

III OBJECTIVES OF INVESTIGATION

- To study the different properties of fly ash and different types of alkaline solutions like NaOH and Na_2SiO_3, GGBS, etc.
- To cast the concrete blocks, beams and cylinders using geopolymers in different proportions and with appropriate molar solutions.
- To perform test on the concrete blocks, beams and cylinders in order to check it's strength.
- To compare the testing results with the OPC i.e. conventional concrete.

IV CONSTITUENTS OF GEOPOLYMER

1. Fly Ash : The first reference to the idea of utilizing coal fly ash in concrete was by McMillan and Powers in 1934 and in subsequent research (Davis et al., 1935, 1937). In the late 1940s, UK research was carried out (Fulton and Marshall, 1956) which led to the construction of the Lednock, Clatworthy and Lubreoch Dams during the 1950s with fly ash as a partial cementitious material. Fly ash, the most widely used mineral admixture in concrete, is a by-product of combustion of pulverized fuel coal in electric furnace power generating plants at 1250°C to 1600° C. Upon ignition in the furnace, most of the volatile matter and carbon in the coal are burned off. During combustion, the mineral impurities of coal (such as clay, feldspar, quartz and shale) fuse in suspension and are carried away from the combustion chamber by the exhaust gases. In the process, the fused material cools and solidifies into spherical glassy particles called 'FLYASH'.

2. GGBS **:** Blast furnace slag is produced as a by-product during the manufacture of iron as a blast furnace. It results from the fusion of limestone flux with ash from coke and siliceous and aluminous residue remaining after the reduction and separation of iron from the ore. Slag is rapidly cooled with water to form a glassy disordered structure. If the slag is allowed to cool too slowly this allows a crystalline well-ordered structure to form which is stable and non-reactive. The properties of cementitious and pozzolana materials depend on their chemical composition, their physical state, and their fineness. This is particularly the case with blast-furnace slag. Since it is a by-product of the production of iron, its composition may differ from different sources but is likely to be reasonably consistent from a given source.However, to develop satisfactory properties it is essential that the molten slag be rapidly chilled (by quenching with water) as it leaves the furnace. This causes the slag to granulate, that is, break up, into sand-sized particles. More important it causes the slag to

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be in a glassy or amorphous state in which it is much more reactive than if allowed to develop a crystalline state by slow cooling. In the latter state, it is suitable as a concrete aggregate but not as a cementitious material. It is important to note that the underground granulated material does not make a good fine aggregate because often the grains are weak, fluffy conglomerates rather than solid particles. To use as a cementitious material, the granulated slag must be ground as fine as or finer than cement. The fineness of grind will (along with the chemical composition and extent of glassiness) determine how rapidly the slag will react in concrete.

3. Alkali Solution : The alkali solution is used for alkalination of GGBS thus leading to polymerization which results in geopolymer binder. Sodium hydroxide and sodium silicate is used as mediums to form alkali solutions. Sodium hydroxide and sodium silicate was purchased from Abhay chemicals, Ahmadnagar. Different concentrations of sodium hydroxide solution were prepared in the Lab. Sodium silicate of 40% concentration and required grade was added to sodium hydroxide solution and the alkali solution was prepared.This solution was prepared 1 day prior to be used and consumed within 36 hours. The solution was prepared and kept covered at room temperature for gel formation.

4. Aggregate : Aggregates provide about 75% of the total volume. They should meet certain requirements with respect to grading, shape, size and strength. Though they are considered inert, they exhibit certain reactivity which is popularly known as AAR (alkali aggregate reactivity or reaction).
Here fine and coarse aggregates were procured from local contractor working on our college site. Various lab tests are conducted on these aggregates to ensure that they are well graded along with other properties essential for in corporating into mix design of concrete.

V REFERENCES

- Geopolymer concrete with fly ash by N A Lloyd and B V Rangan (Marche Polytechnic University, Ancona, Italy in June 2010)
- GPC an eco-friendly construction material by L. Krishnan, S. Karthikeyan, S Nathiya, K. Suganya (IJRET: International Journal of Research in Engineering and Technology, in June 2014)
- A Review on Strength and Durability Studies on Geopolymer Concrete by Shriram Marathe, Mithanthaya I R, N Bhavani Shankar Rao (Department of Civil Engineering, NMAMIT, Nitte, India)
- Study of the Strength Geopolymer Concrete with Alkaline Solution of Varying Molarities by A.Maria Rajesh1, M.Adams Joe, Roy Mammen (ACEW, Nagercoil, Tamilnadu, India)
- GPC for green environment by B. Vijaya Rangan (The Indian Concrete Journal in April 2014)