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## A Survey on Recycling of GGBS into Geopolymer Concrete and Creating Eco-Friendly Cement Product

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**ABSTRACT:** Cement industry is one of the vital contributors to the emission of greenhouse gasses. That is cement production consumes large amount of virgin materials in atmosphere, which is one of cause of global warming. Also, in India more than 100 million tons of fly ash is produced annually. Fly ash was chosen as the basic material to be activated by the Geopolymerisation process to be the concrete binder, to totally replace the use of Portland cement. For the polymerization the sodium hydroxide and potassium hydroxide were used in three combination process. The some parameter assumed as fixed with past literature review. The other parameter like temperature, curing time and testing age were analyze with different type of the activator. The activators were used like sodium hydroxide, potassium hydroxide and 50% of sodium hydroxide, 50 % of potassium hydroxide. The compressive strength test used for the optimization of temperature and curing time of geopolymer concrete. In this study solution to fly ash ratio of 0.45 with 10 Mole concentrated sodium hydroxide solution and potassium hydroxide is used and grade chosen for investigation was M30. All the specimens were cured in oven at 80<sup>0</sup>C for 24 hours duration. All tests were conducted according to Indian standard code procedure. Test results for compressive strength, split tensile strength and flexure strength are tabulated and discussed in details and some important conclusions are made.

**KEYWORDS:** Fly Ash, GGBS, Geopolymer Concrete, Cement Product, OPC.

### I. INTRODUCTION

#### 1.1 General

Mostly worldwide use of concrete is second the pollution due to factory smoke or other materials. Basically in civil construction concrete is an important parameter and cement is a main key factor of concrete material. One tone of cement manufacture produced one tone carbon dioxide. The carbon dioxide affects human health and surrounding environment. It is responsible for many serious problems. Now the world is focusing on eco-friendly material and products. In this project, attempts are made to replace cement by GGBS and FA which is an industrial waste material. There is also problem of disposal of this material. An expressive use of GGBS and FA in GPC material. Geopolymer concrete has excellent properties, as a researcher has already studied. The cement consumption has risen nearly more than 1.3 billion tons per annum. CO<sub>2</sub> is emitted during the calcination of limestone, resulting in an approximately 1 ton of CO<sub>2</sub> for every ton of OPC produced. So to reduce the Greenhouse gas, we need to control the emission of CO<sub>2</sub>. Therefore its need of the time to not only introduce such materials and technologies for an alternative to the cement but also to use it more and more. Replacing 15% of cement worldwide by other cementation material will reduce CO<sub>2</sub> emission by 250 million tons and if it's replaced by 50 %, emission is reduced by 800 million tonnes. Our Project Aim is to completely replace the cement by fly ash which is used as a binder in Geopolymer Concrete. At

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present nearly 170 million tonnes of fly ash is being generated in India and its utilization is only 25 million tonnes. So the disposal of fly ash and GGBS is also a major issue.

## 1.2. Geopolymerization Starts with Oligomers:

Geopolymerization is the process of combining many small molecules known as oligomers into a covalently bonded network. The geo-chemical syntheses are carried out through oligomers which provide the actual unit structures of the three dimensional macromolecular edifice. In 2000, T.W. Swaddle and his team proved the existence of soluble isolated alumino-silicate molecules in solution in relatively high concentrations and high pH. One major improvement in their research was that their study was carried out at very low temperatures, as low as 9 °C. Indeed, it was discovered that the polymerization at room temperature of oligo-sialates was taking place on a time scale of around 100 milliseconds, i.e. 100 to 1000 times faster than the polymerization of ortho-silicate, oligo-siloxo units. At room temperature or higher, the reaction is so fast that it cannot be detected with conventional analytical equipment.

## 1.3 Research Significance:

In this research, an effort has made to understand the properties of geopolymer concrete and cement replaced by GGBS and Fly Ash at a different percentage. Focus is on mixing design of Geopolymer concrete and curing type and temperature. Also effects on the properties of GPC. To find out the compression and tensile strength of the concrete.

## 1.4 Objectives:

1. To examine the properties of GGBS and Fly Ash as the alternative material of OPC.
2. To find the economical, technical, and environmental limits of GGBS and Fly Ash over OPC.
3. To determine compressive and tensile and flexural strength of Geopolymer concrete.
4. To write a conclusion on Geopolymer concrete whether good alternative material of conventional Portland cement.

## II. LITERATURE REVIEW

**Joseph Davidovits (1994)** studied of properties geopolymer cement carried out by the author. Researcher focused on excellent properties of geopolymer and its use regarding rehabilitation of retrofitting of structures after a disaster. The geopolymer is the best material for retrofitting regarding the environmental and construction usages.

**Lyon E et al (1996)** studied that geopolymer is noncombustible and fire resistive structural materials. Which are suitable for infrastructure where a high degree of fire resistance is needed at low to moderate cost. The main conclusion was entered that load bearing capability increases with increasing fire up to 100<sup>0</sup>C temperature might be reached.

**Balaguru. P (1997)** from this paper it is being concluded that study has been done with the help of geopolymer concrete for repair and rehabilitation RCC beam. The first objective of this paper was to know whether geopolymer can be used or not for repair of the concrete structure. It has been also concluded that geopolymer concrete has the strongest bond with carbon fabrics.

**VijayaRangan B (2004)** carried out a study on durability of geopolymer concrete by considering the environmental protection. This paper described the results by conducting the test by large scale reinforced geopolymer concrete member and also give the application of geopolymer concrete in the construction industry. The test gave the results regarding excellent to resistance to sulfate attack and fire undergoes low creep was noted the based benefit of geopolymer concrete

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**VijayaRangan et al (2006)** studied the behavior of fly ash based Geopolymer concrete and informed that the geopolymer concrete had an excellent compressive strength and is suitable for the structural applications. The elastic properties of the hardened concrete, as well as the behavior and strength of the reinforced structural members, were similar to those of Portland cement concrete. Therefore, the design provisions present in the current standards and codes can be used to design the reinforced fly ash-based geopolymer concrete structural members.

**Sumajouw D.M.J et al (2006)** Studied of the behavior of fly ash and slender reinforced columns. They studied analysis of the behavior and the strength of reinforced geopolymer concrete slender columns. The low calcium fly ash based geopolymer concrete reinforced columns had excellent potential in the precast industry.

**Bhikshma et al. (2010)** In this paper author investigated that flexural behavior of high strength manufacture sand concrete. The researcher observes the workability of M50 grade investigated sand concrete is supposed to be 30% less compared to ordinary concrete and compressive strength of M50 grade concrete having varying percentages that are 0%, 25%, 50%, 75%, 100%. Manufacture concrete improves the strengths by 6.89%, 10.76%, 20.68% respectively and the outcome was while comparing to ordinary concrete the load carrying and moment carrying capacity of reinforced concrete beam was 3 to 12 % higher.

**Vijai et al (2010)** informed that geopolymer concrete had an excellent compressive strength and it is more suitable for the structural application. The elastic as well as behavior and strength properties of reinforced structure members here similar to those of portland cement concrete. Hence the design provisions according to the current codes and standards can be used to design the reinforced fly ash-based geopolymer concrete member structure.

**Abdul Aleem M.I and Arumairaj (2012)** made an endeavor to discover an optimum mix for the Geo-polymer concrete and they have casted concrete cubes of size 150 x 150 x 150 mm and cured under Steam curing at 24 hours based on the compressive strength. The possible mix is Fly ash: Fine aggregate: Coarse aggregate (1:1.5:3.3) with a solution (NaOH & Na<sub>2</sub>SiO<sub>3</sub> mix together) to fly ash ratio of 0.35. High and early strength was gotten in the Geopolymer concrete mix.

**Abdul Aleem M.I and Arumairaj P.D (2012)** has surveyed that on Geopolymer concrete. It was presented that due to the high early strength Geopolymer Concrete shall be effectively used in the precast industries, so great production is possible in short duration and the breakage at time of transportation shall also be minimized. They find the characteristics of geopolymer concrete and said that Geopolymer Concrete can be used in place of ordinary Portland cement concrete.

**Ganpathinaidu.P et al (2012)** find out a Study on strength properties of Geopolymer concrete with addition of GGBS. At this attempt was made to study the strength properties of Geopolymer concrete using Low calcium fly ash replaced with slag in 5 different percentage. They find Compressive strength of geopolymer concrete increases with increase at percentage of replacement of fly ash with GGBS was up to 28.57% of replacement of fly ash by GGBS, the setting was normal and fast setting was found. They found that maximum of 25% loss in compressive strength was observed when geopolymer exposed to a temperature of 500C for two hours.

**Madheswaran C.K et.al (2013)** examined the variation of strength for different grades of geo polymer concrete by varying the molarities of sodium hydroxide. Different molarities of NaOH (3M, 5M, and 7M) were taken to get ready different mixes and cured in the ambient temperature. GPC mix created with compressive strength ranging from 15 to 52 MPa had been obtained. The cubes were tested for their compressive strengths at the age of 7 and 28 days. The compressive strength of GPC expanded with expanding concentration of NaOH.

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**Mahesh Patel et al. (2013)**, stated that the Strength of High Performance Concrete with GGBS and Crusher Sand by replacing the fine aggregates by crusher sand and cement by CGBS. It was discovered that the 20% replacement of fine aggregates by crusher sand was optimum, in view based on the Compressive strength and Split Tensile strength.

## III. METHODOLOGY

### 3.1 Introduction

This section includes planning of project work and step by step all detail explanations about work which as follows.

### 3.2 Experiment Procedure:

Before starting the project work study of many research papers which give me basic of carrying out my experiment work. After referring various papers material finalization done and following project work was followed.

- Selection of material like Coarse aggregate, fine aggregate, Fly Ash, GGBS, Polymer and catalyst
- Laboratory test on were performed on Coarse Aggregate, Fine Aggregate, GGBS, Fly Ash, Catalyst Activator, Polymer Activator
- Mix Design was done for M30 Grade of Concrete.
- Cement is fully replaced by Fly Ash and GGBS.
- Workability of concrete was checked.
- Determining the compressive, Split tensile and flexural strength of concrete of different mix.
- Determining these strengths by 80<sup>0</sup> c for 24 hours steam curing.
- Flexural strength of concrete is determined by the flexural testing machine.

## IV. CONCLUSION

For Geopolymer concrete the curing time and temperature variation play important role for polymerization. The 24 hours of curing time shows the significant result. The potassium hydroxide to sodium hydroxide ratio 1 shows the significant properties of geopolymer concrete. The sodium hydroxide is cheaper than the potassium hydroxide shows near about same mechanical properties of geopolymer concrete. Longer curing time improved the polymerization process resulting in higher compressive strength of Geopolymer concrete for optimized temperature. Geopolymer concrete is more environmental friendly. It has the potential to replace cement from concrete in many applications such as pre-cast units. The future scope of this project is GGBS and Fly Ash is waste generate having disposal problem and it is generated from domestic use and industrial use. Study on the addition of various concentrated of molarity on Geopolymer concrete and their effect on enhancement of strengths. Achieving ultra-high strength of geopolymer concrete by addition of GGBS, Fly Ash, Catalyst activator and polymer activator. Investigate on the effect of varying curing period and curing type on strength properties of geopolymer concrete. GGBS and Fly Ash used instead of cement resulting economy up to a certain limit. The effect of temperature on the concrete developed can be studied hence environment eco-friendly concrete product.

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