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# Study of Geopolymer Based Bacterial Concrete

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***Abstract*** *- The increasing emphasis on energy conservation and environmental protection has led to the investigation of alternatives to customary building material. The effort is urgently underway all over the world to develop environment-friendly construction materials that make minimum utility of natural resources and helps to reduce greenhouse gas emissions. The contribution of greenhouse gas emission due to ordinary Portland cement production worldwide is approximately 7%. For each ton of Portland cement manufactures, it is estimated that one ton of CO2 is released into the environment. Compared to Portland cement, fly ash-based geopolymer concrete can reduce carbon emissions by 80%, which has the potential to reduce global emissions by approximately 2.1 billion tons a year. In this connection, Geopolymers are showing great potential and does not need the presence of Portland cement as a binder. This research report presents a study on the Study of Geopolymer Based bacterial Concrete.*

**Keywords** - *Geopolymer concrete, Bacterial concrete, Fly ash, Rice husk, self-healing concrete.*

## I. INTRODUCTION

The environmental impact associated with the production processes of Ordinary Portland Cement (OPC) includes Greenhouse gas emissions High energy consumption. Natural resources exploitation. Partially replace the use of cement in concrete Develop alternate materials. In the last 20 years, the increased need to design and formulate green materials significantly contributed to developing innovative researches on environmentally friendly substitutes for Portland cement, along with ways of reusing industrial waste and by-products.

OPC can be the replacement by supplementary cementing materials, such as Fly Ash (FA), Ground Granulated Blast furnace Slag (GGBS), Silica Fume, Rice Husk Ash, Metakaolin. The cement industry is a major source of carbon emissions and deserves attention in the assessment of carbon emission-reduction options. It is responsible for about 6% of all CO2 emissions because the production of one ton of Portland cement emits approximately one ton of CO2 into the atmosphere (Davidovits, 1994c and Mc Caffrey, 2002). The contribution of Ordinary Portland Cement (OPC) production worldwide to greenhouse gas emissions is estimated to be approximately 1.35 billion tons annually or approximately 7% of the total greenhouse gas emission to the earth's atmosphere (Malhotra, 2002).

## II. GEO POLYMER CONCRETE (GPC)

The New technology GPC is a promising technique and eco-friendly alternative to OPC. Geopolymer is produced by a polymeric reaction of alkaline liquid with source material of natural minerals or by-product materials without cement.

Concrete is the most commonly used construction material in the world due to its high compressive strength, durability, and availability. One of the efforts to produce more environment-friendly concrete is to partially replace the amount of OPC in concrete with by-product materials such as fly ash.

Fly ash is a residue from the combustion of coal, which is widely available worldwide and leads to waste disposal proposal problems. Recent research has shown that it is possible to use 100% of fly ash as the binder in the mortar by activating it with an alkali component, such as silicate salts and non-silicate salts of weak acids ( Bakharev et al. (1999a), Talling et al. (1989)).

In fly ash-based geopolymer concrete, the silica and the alumina present in the source materials are first induced by alkaline activators to form a gel known as aluminosilicate. This gel binds the loose aggregates materials in the mixture to form the geopolymer concrete (Wallah, 2010). This inorganic aluminosilicate polymer is called a geopolymer.

## III. BACTERIAL CONCRETE

The process can occur inside or outside the microbial cell or even some distance away within the concrete. Often bacterial activities simply trigger a change in solution chemistry that leads to over-saturation and mineral precipitation. The use of these Bio mineralogy concepts in concrete leads to the potential invention of new material called ―Bacterial Concrete. The bacterial concrete can be made by embedding bacteria in the concrete that are able to constantly precipitate calcite. This phenomenon is called microbiologically induced calcite precipitation.

Bacterial Concrete is also called as Bio concrete or Self-healing concrete. It is specially made to increase the lifespan or the durability of concrete structure by the self-healing action of that concrete. A two-component healing agent is added to the concrete mixture. The agent consists of bacteria and an organic mineral precursor compound.

## IV. GEOPOLYMER BASED BACTERIAL CONCRETE

The geo polymerization processes will be carried out by complete substitution of OPC to Supplementary Cementations Materials (SCM) added with an alkaline liquid and adding Bacteria with Calcium Lactate resulting in geo polymer-based bacterial concrete composites, which improves the mechanical and durability properties of concrete. This improvement will be due to GPC temperature conditions to survive more microorganisms to produce more calcite than conventional concrete.

Bacillus species is an ureolytic bacterium that can produce calcite to decrease concrete pores for enhancing strength and durability. Various Bacillus spices of spore-forming bacteria have been used by researchers in their studies: I.e.

- ✓ Bacillus pasteurii,
- ✓ Bacillus sphaericus,
- ✓ Bacillus cohnii,
- ✓ Bacillus pseudofirmus ,
- ✓ Bacillus subtilis,
- ✓ Bacillus Megaterium, and
- ✓ Bacillus alkalinitrilicus.

This research actually investigates the ability of Bacillus bacteria species to improve the strength and durability of GPC based on calcification and Geopolymerization processes.

## V. LITERATURE REVIEW

**Ramin Andalib et Dec 2015** reported that Bacillus bacteria had a favorable outcome on the compressive strength and durability of GPC. The highest strength growth was obtained in Geopolymer bacterial concrete with a 30x105 concentration of microorganism. This improvement was due to GPC temperature conditions to survive more microorganisms to produce more calcite. The durability study also proved with evidence that the Geopolymer bacterial concrete had less weight and strength losses than the ordinary and GPC without microorganisms in 5% H2SO4 solution.

Ultrasonic pulse velocity (UPV) test result verified that the density and uniformity of Geopolymer bacterial concrete were more than other types of concrete in this research. This improvement was due to filler substance of biology within the concrete pores as a result of microbiologically induced mineral precipitation and GPC materials component size.

**Partha Sarathi Deb, Pradip Nath, Prabir Kumar Sarker 2014** represents the workability of GPC decreased with the increase of GGBS content together with FA in the binder when the other mixture variables remained the same. The addition of GGBS enhanced the setting of the concrete at ambient temperature. Compressive strength at all ages up to 180 days increased with the increase of the GGBS content. Strength development of the GGBS blended FA GPC cured at ambient temperature was similar to that of water-cured OPC concrete.

The strength gain slowed down after the age of 28 days and continued to increase at a slower rate until 180 days. Tensile strength of ambient cured GPC increased with the increase of compressive strength. The effect of the mixture variables on the development of tensile strength was similar to that on the development of compressive strength.

**N.K. Lee, H.K. Lee 2013** presents the setting times of alkali-activated FA/GGBS paste decreased as the amounts of GGBS and the molarity of the NaOH solution increases. The compressive strengths of the alkali-activated FA/GGBS concrete at 28 days increased with the amount of GGBS. The appropriate % of GGBS is 15–20%, considering the setting time, workability, and development of compressive strength.

The mean pore sizes of the alkali-activated FA/GGBS mortars were smaller than that of OPC specimens. This indicates that high shrinkage due to the increased number of small pores caused micro-cracks in the alkali-activated FA/GGBS concrete, resulting in decreases in the elastic modulus and the long-term compressive strength.

**B.Singh, M.R.Rahman, R.Paswan, S.K.Bhattacharyya 2016** indicated that Activator concentration is a significant factor in controlling the geopolymer formation, microstructure, and strength of the hardened concrete. Above optimum activator concentration (14 M), the compressive strength of concrete decreased probably due to the hard microstructure and the differences between the phase composition at the aggregate-paste interface and the bulk matrix. At an early age, the experimental compressive strength of FA/GGBS GPC was higher than the calculated from the equation of OPC concrete due to the rapid polymerization reaction.

It was noted that the elastic modulus of FA/GGBS GPC was lower than predicted from the Indian design Code for OPC concrete because of differences in the volumetric percentage of aggregate and the nature of the binder. Impact resistance of specimens increased with the increase of their compressive strength due to the satisfactory bonding between the paste and aggregate.

The drying shrinkage in GPC was very small after 6 months and also falls well below the reported value of OPC concrete. It was observed that GPC based on FA/GGBS composite mix with an optimum activator concentration developed desired setting and hardening at room temperature.

**Virginie Wiktor, Henk M.Jonkers 2011** reported that studies show that the applied two-component bio-chemical self-healing agent, consisting of a mixture of bacterial spores and calcium lactate, can be successfully applied to promote and enhance the self-healing capacity of concrete as the maximum healable crack width more than doubled.

Moreover, oxygen measurements provided evidence that concrete incorporating bacterial spores embedded in expanded clay particles and derived active bacteria remain viable and functional several months after concrete casting. The microbial enhanced crack-healing ability is presumably due to combined direct and indirect calcium carbonate formation: (i) direct $CaCO3$ precipitation through the metabolic conversion of calcium lactate and (ii) indirect formation due to reaction of metabolically produced $CO2$ molecules with $Ca(OH)2$ minerals present in the concrete matrix leading to additional $CaCO3$ precipitation.

In addition, as the metabolically active bacteria consume oxygen, the healing agent may act as an oxygen diffusion barrier protecting the steel reinforcement against corrosion. So far, bacteria have never been used to remove oxygen from the concrete matrix to inhibit reinforcement corrosion, and further studies are needed to quantify this potentially additional beneficial process. While in this study, the enhanced self-healing capacity of bacteria-based concrete has been quantified, several other characteristics such as long-term (years) durability and cost efficiency of this novel type of concrete need to be resolved before the practical application can be considered. Anticipated potential advantages of this bacteria-based concrete are presumably primarily in the reduction of maintenance and repair costs and extension of the service life of concrete constructions.

## VI. TESTS ON GEOPOLYMER BASED BACTERIAL CONCRETE

### *A.Test to be conducted on Fresh concrete*

- ✓ Slump test
- ✓ Compaction factor test

### *B. Tests to be conducted to determine the Mechanical properties of concrete*

- ✓ Compression test
- ✓ Split Tensile test
- ✓ Flexural strength test
- ✓ Impact strength test
- ✓ Surface hardness test
- ✓ Modulus of Elasticity

### *C. Tests to be conducted to determine the Durability properties of concrete*

- ✓ Water absorption test
- ✓ Sorptivity test
- ✓ A rapid chloride penetration test
- ✓ Permeability
- ✓ Acid resistance test

## VII. MATERIAL COLLECTION

### *A. Ingredients*

- ✓ Pulverized Fuel Ash (PFA)
- ✓ GGBS (Ground Granulated Blast Furnished Slag)
- ✓ Sodium Silicate
- ✓ Sodium Hydroxide
- ✓ Aggregates (Coarse & Fine Aggregates)
- ✓ Water
- ✓ Chemical Admixture
- ✓ Bacteria

### *B. Test Performed in Lab for the Ingredients*

- ✓ **PFA & GGBS**
- ✓ Physical Tests
- ✓ Chemical Tests
- ✓ **Coarse Aggregates**
- ✓ Sieve Analysis
- ✓ Wet Sieve Analysis
- ✓ Specific Gravity
- ✓ Water Absorption
- ✓ Impact Value
- ✓ Crushing Value
- ✓ Flakiness Index
- ✓ Elongation Index
- ✓ Dry Loose Bulk Density

## VIII. Problem Statement

The world is facing the challenge of global warming and climate changes due to carbon dioxide ($CO2$) greenhouse gases and increment of $CO2$ concentration. According to current trends and development, the industrial sector has a big challenge

To maintain a high quality of life while ensuring low energy consumptions and CO2 emissions. Sustainable development of technologies for industrial waste utilization to building construction areas. is given considerable worldwide attention due to their advantages of greenhouse gas reduction from Portland cement production and applications in waste management.

Introducing Geopolymer Materials not only for the environmental issue but also for reduction of carbon dioxide emission caused by 80% to 90% of Ordinary Portland Cement (OPC) in building construction. Due to the absence of cement in geopolymer mixtures, many researchers believe that geopolymer concrete will be the future concrete.

## IX. CONCLUSION

- To produce an alternate material for cement & a sustainable green concrete for conventional cement concrete.
- To reduce the environmental impact, the Industrial by-product is used in concrete.
- To improve the mechanical behavior of concrete.
- To enhance the durability of concrete.
- To enhance optimum strengths in GPC by using bacteria.
- Formulation of new charts and comparison of various parameters in Geo polymer-based Bacterial Concrete.

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