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STUDY ON GEOPOLYMER CONCRETE

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ABSTRACT

Concrete, which consists of cement, aggregates, water, and additives, is the most widely used building material in the world because it is more adaptable, dependable, and durable. After water, concrete is the second most consumed material, requiring a lot of Portland cement. Because of the CO2 emissions during the production of Ordinary Portland Cement (OPC), the environment is destroyed. Mining also causes irreversible harm to the natural world. The amount of carbon emissions is rising alarmingly, thus finding a substitute for the pricy cement-concrete that is now in use is necessary. Inorganic molecules combine chemically to produce geopolymer concrete, an alternative construction material. Around the world, fly ash, a byproduct of coal from thermal power plants, is widely accessible. Fly ash, abundant in silica and alumina, when activated with alkaline activators, forms an aluminosilicate gel that serves as the concrete's binding agent.It is a great substitute for regular concrete in building that requires very little regular Portland cement. In some cases, geopolymer concrete proves to be a more environmentally friendly option than regular Portland cement concrete. This essay examines the uses and structural characteristics of geopolymer concrete.

Key Words: geopolymer concrete, fly ash, GGBFS, alkaline solutions.

1. INTRODUCTION

One of the sectors of the global economy that is expanding the fastest is the construction sector. One of the most often utilised building materials is concrete. Ordinary Portland Cement is the main binder used in concrete (OPC). Global cement production is estimated to be as high as 2.6 billion tonnes annually, producing around 7% of carbon dioxide, a major contributor to environmental pollution and global warming [3]. Large amounts of limestone, which are running out, are also needed for cement manufacture. However, a significant amount of fly ash, a byproduct of burning coal, is created, and most of it is dumped in landfills, which has an impact on both surface and groundwater resources. Therefore, it is crucial to employ alternative pozzolan elements that will lessen the negative effects of building on the environment, use waste that is created, and increase the performance of concrete.

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2. OVERVIEW ON GEOPOLYMER CONCRETE

Numerous investigations have been conducted to tackle the aforementioned ecological issues. Fly ash, silica fume, ground-granulated blast furnace slag (GGBFS), and rice husk ash are some of the alternative pozzolan constituents. The term "geopolymer" was initially developed by French Professor Davisovits. As an alternative to traditional concrete, geopolymer concrete uses rich silica and alumina-containing source materials to improve the binding qualities without requiring cement as a binder. The interaction of alkaline solutions with the pozzolan source material results in the binding property[3].The combination of the source material and the alkaline solution results in an aluminosilicate gel. To create geopolymer concrete, the aggregates and other components are bound together by the gel that has formed.

3. LITERATUREREVIEW

M. Mohd et al "A review on fly-ash based geopolymer concrete without Portland cement" was the subject of M. Mohd et al.'s study. Numerous factors were examined in the study, including the geopolymer's behaviour at high temperatures, its tolerance to harsh environments, its workability, compressive strength, and curing process. The investigation found that fly ash-based geopolymer concrete is superior to regular concrete in a number of areas, including workability, exposure to harsh environments, increased temperatures, and compressive strength.

B. Singh et al examined the subject of "A Review of Some Decent Developments in Geopolymer Concrete."

Numerous factors, including the C-S-H phase effect, the impact of admixtures, curing conditions, geopolymer mortars, the fresh and hardened characteristics of geopolymer concrete, and durability, were taken into consideration in the study. According to the study's findings, geopolymer concrete offers a lot of promise for usage as a building material in many contexts.

J. Bhushan et al examined the subject of "A review of geopolymer concrete."The study included a wide range of topics, including compressive strength, longevity, the financial advantages of geopolymer concrete, its need, and its application. According to the study's findings, geopolymer concrete has high compressive and tensile strengths and is resistant to fire and corrosion.

M. I. Abdul Aleem et al. examined the subject of "A review of geopolymer concrete." Numerous factors were examined in the study, including the requirement of geopolymer concrete, its elements and qualities, its applications, and its limits. The study found that because of its high early strength, geopolymer concrete should be employed successfully in the precast industries to enable large production in a short amount of time and to reduce breakage during transportation.

Marathe S. et al. Review of strength and durability tests on geopolymer concrete was the subject of study. Numerous parameters were examined in the study, including the materials used to make geopolymer concrete, the proportions and characteristics of the mixing process, the workability of fresh geopolymer, the casting and curing of the geopolymer specimen, and the main hardened properties of the geopolymer concrete. The study found that because geopolymer concrete (GPC) is both environmentally benign and has outstanding mechanical qualities, it has a great deal of potential as an engineering material for future research.

4. GEOPOLYMER CONCRETE MATERIALS

A. Fly Ash

When utilised in place of cement in concrete, this byproduct from the burning of coal in thermal power plants with high silica and alumina content would help lessen the negative environmental effects.

B. GGBFS

An acronym for ground granulated blast furnace slag, which comes in fine powder form and is derived from the iron and steel industries. GGBFS is granular and glassy in nature, including silicates and alumina.

C. Aggregates

Conventional fine and course aggregates of standard sizes are used in geopolymer concrete.

D. Alkaline Solutions

Potassium and sodium hydroxides and silicates are used. By interacting with silica and alumina from source materials like fly ash and GGBFS, these alkaline solutions will create binders that provide concrete strength.

COMPARISON OF STRENGTH PARAMETERS

A. Compressive Strength

Marathe S. et al. centred on the subject of "Examination of Geopolymer Concrete Strength and Durability Studies." Study topics included the raw materials for the creation of geopolymer, different mix ratios, characteristics that determine strength, the workability of the material while it's new, the casting and curing processes, and more. The study found that because geopolymer concrete (GPC) is both environmentally benign and has outstanding mechanical qualities, it has a great deal of potential as an engineering material for further investigation.

Vijya Rangan et .al. claimed that, in comparison to regular concrete, the compressive strength of geopolymer concrete is extremely high. About 1.5 times as high as regular concrete, using the same mix. In comparison to regular concrete, geopolymer concrete also demonstrated excellent workability.

B. Durability

“Geopolymer concrete is more resistant to heat, sulphate assault, water infiltration, and alkali-aggregate reaction, according to Rangan, B.V. et al. In fly ash-based geopolymer concrete, calcium plays a major role since it can lead to flashsetting. These extremely durable constructions may be adjusted to the maritime environment

According to Walid et al., heat-cured fly-ash-based geopolymer concrete exhibits minimal creep and drying shrinkage, with only around 100 micro strains observed after a year. Moreover, it exhibits outstanding defence against sulphate assault. Chanhetal shown that a geopolymer based on fly ash provides better resistance to a severe environment. As a result, this resistivity characteristic may be used for building structures that are exposed to the sea[10].In contrast to regular concrete submerged in 3% sulfuric acid, Sathia et al. demonstrated that only 0.5% of weight is lost when geopolymer is subjected to an acid solution.

C. Workability of fresh geopolymer concrete

According to a research by Sathia et al., water is just as crucial to geopolymer concrete as it is to regular concrete. Watering down a polymer can enhance workability, but at higher temperatures, it will cause more porosity in the concrete when water evaporates during the curing process.

According to Chinda Prasirt et al., a rise in the concentrations of sodium silicate and hydroxide causes a decrease in mortar flow. Geopolymer mortar had a workable flow between 110 ± 5 and 135 ± 5% [12].

Superplasticizer or more water can improve the workability of mortar, however using superplasticizer reduces the geopolymer's strength. Although adding more water results in a stronger mixture than adding superplasticizer..

D. Economic Benefits of Geopolymer Concrete

Heat-cured, low-calcium flyash-based geopolymer concrete is thought to be around 10 to 30 percent less expensive than Portland cement concrete, according to Lloyd and BVRangan's conclusion. Furthermore, using one tonne of coal responsibly yields around one carbon credit, making it more economically viable from an ecological standpoint.

Three cubic metres of excellent fly ash-based geopolymer concrete may be produced from one tonne of low-calcium fly ash. The little drying shrinkage, minimal creep, and superior resilience that geopolymer concrete offers when used in infrastructure have further financial advantages.

Comparing geopolymer concrete to conventional concrete, there are several benefits. It requires less maintenance and is more durable than regular concrete, saving a significant amount of money on repairs and upkeep for concrete-based infrastructure.

Necessity of Geoploymer Concrete

There will be a severe scarcity of limestone in the future due to the massive expansion in infrastructure construction and the use of cement, which reached 3,294 million tonnes in 2010 and is growing by about 12% annually, according to reports from the International Cement Review. Furthermore, CO2 emissions into the atmosphere will cause global warming.According to the estimate provided by Kumar V. et al. (2005), fly ash production in the thermal power sector is anticipated to reach around 170 million tonnes by 2012 and 225 million tonnes by 2017.

According to Lokeshappa et al., only 38% of fly ash is used in the building industry, and the area where the remaining fly ash is disposed of pollutes the environment. Therefore, it is crucial to conduct research and development in order to examine the structural qualities of fly ash and to make use of industrial wastes in building.

According to the aforementioned study, more industrial waste may be used in the building industry with the development of geopolymer concrete, which will also help to mitigate global warming by reducing the use of Portland cement.

E. Applications

Aleem et al. pointed out that if geopolymer concrete can be utilised in the precast industries and transportation-related breaks are minimised, then massive output may be achieved quickly. It will function well for infrastructure projects and the beam-column connection of reinforced concrete structures. Fly ash will therefore be utilised efficiently, and no landfills will be needed to dispose of the fly ash [5].

According to Anuar et al., Davidov's Geopolymer technology holds great potential for use in the concrete industry as a substitute for Portland cement as a binder. It can be used to produce precast railway sleepers and other pre-stressed concrete building components .

F. Challenges

Before geopolymer concrete is used in real construction, there are a few obstacles that need to be addressed in addition to the many benefits that are anticipated. Hazardous chemicals are utilised in geopolymer concrete. Delivering the basic material flyash to its designated spot. Alkaline solutions are expensive. Applying the steam curing/high temperature curing technique presents practical challenges .Extensive research is being conducted to build geopolymer systems in order to get past these technological obstacles.

5. COMPARISON OF STRENGTH PARAMETERS

The following findings from a comparison study between conventional and green concrete were given by Y. Nagvekar et al.The study used an M25 grade of concrete mix and employed two distinct curing methods: steam curing and water immersed curing, often known as conventional curing. The cubes were evaluated for their compressive strengths for three, seven, and twenty-eight days. The following findings were reported.

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Table1: 3 days Compressive Strength

Compressive Strength Test Results after 3days			
Sl.No.	Conventional Concrete(N/mm^2)	Geopolymer Concrete (Water Submerged Curing)N/mm^2	Geopolymer Concrete(Steam Curing)N/mm^2
1	10.13	4.63	15.6

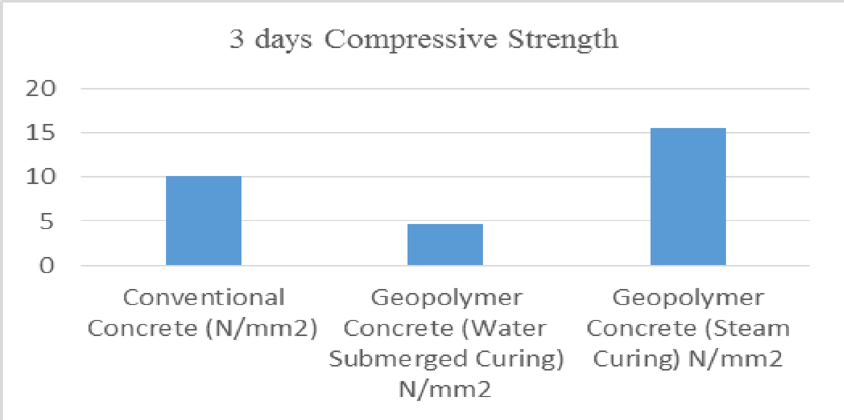

Figure.1

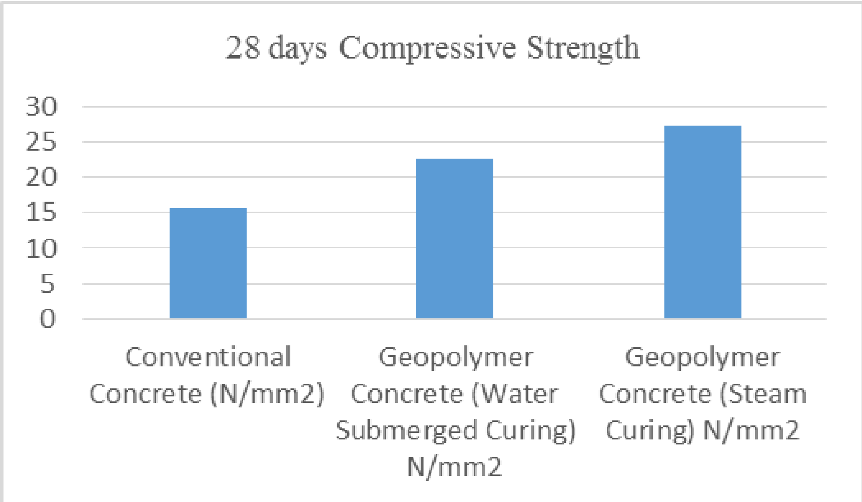

Figure2: 3 days Compressive Strength

Table2:7daysCompressiveStrength

Compressive Strength Test Results after 7 days			
Sl.No.	Conventional Concrete(N/mm^2)	Geopolymer Concrete (Water Submerged Curing)N/mm^2	Geopolymer Concrete(Steam Curing)N/mm^2
1	15.13	8.4	22.6

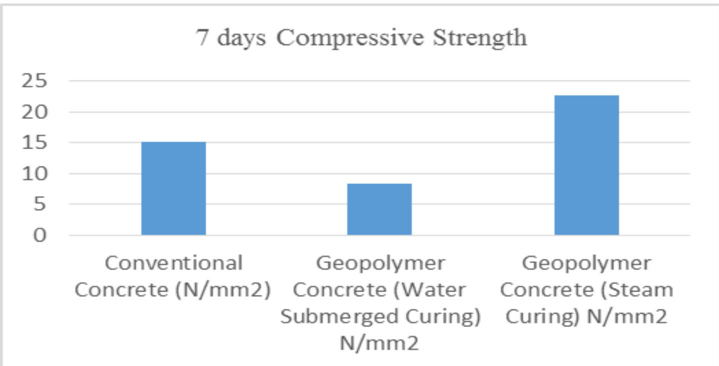

Figure3 :7 days Compressive Strength

T**able 3**:28 days Compressive Strength

Compressive Strength Test Results after 28 days			
Sl. No.	Conventional Concrete(N/mm^2)	Geopolymer Concrete (Water Submerged Curing)N/mm^2	Geopolymer Concrete(Steam Curing)N/mm^2
1	15.6	22.6	27.53

The author deduced from the experimental findings that conventional concrete has a higher compressive strength than geopolymer/green concrete when it is submerged in water and allowed to cure. Nonetheless, the strength of geopolymer concrete is 10% more than that of regular concrete when steam curing is used. Therefore, steam curing is preferable than water immersed curing for geopolymer concrete.

6. CONCLUSIONS

It may be inferred from several research that fly ash-basedBecause of its many advantages over regular concrete, including its superior compressive strength, resistance to harsh environments, workability, and exposure to high temperatures, geopolymer is chosen. According to the study, geopolymer concrete has higher compressive and tensile strengths, is more resistant to fire and corrosion, and regains its full strength more rapidly.In addition, there is less shrinkage than with regular concrete. Therefore, considering these structural benefits, it can be said that geopolymer concrete may prove to be a viable replacement for traditional cement concrete in the near future. Research has shown that in order to reach a consensus about the benefits and drawbacks of geopolymer concrete, a thorough investigation is necessary.

Geopolymer concrete is easily used in accordance with the same guidelines that govern regular Portland cement concrete. These components of geopolymer concrete may be combined with a low-alkali activating solution and, under natural circumstances, they cure quickly.Similar to Portland cement, this geopolymer concrete may be mixed and dried with success.

Geopolymer concrete can be used for repair and renovation works Geopolymer concrete may be efficiently employed in the precast industries because of its early high strength quality, which allows for large production to be completed in a short amount of time and little transportation-related breaking. For the beam-column connection of a reinforced concrete construction, geopolymer concrete can be employed with good results.

Additionally, geopolymer concrete must be employed effectively in infrastructure projects. Furthermore, fly ash will be utilised efficiently, so there is no need to dump it in landfills. Geopolymer concrete becomes stronger when steam-cured rather than soaked in water during the curing process. Steam curing increases the strength by ten percent. The government can take the appropriate actions to extract sodium hydroxide and sodium silicate solution from chemical industry waste materials, which would lower the cost of the alkaline solutions needed to make geopolymer concrete.

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