



Experimental Analysis on Geopolymer Self-Cleaning Concrete Utilizing Fly Ash and GGBS - A Literature Review

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ABSTRACT—

An increasing need for eco-friendly and long-lasting construction materials has pushed the industry to find alternatives to Portland cement concrete, such as geopolymer concrete. Geopolymer self-cleaning concrete based on fly ash and ground granulated blast furnace slag (GGBS) is investigated in this study for its mechanical properties, durability, and self-cleaning efficacy. Sodium hydroxide (NaOH) and sodium silicate (Na_2SiO_3) form an alkaline solution that activates fly ash and GGBS, the primary aluminosilicate binders. Titanium dioxide (TiO_2) is a photocatalytic substance that may self-clean when exposed to light and undergoes photocatalytic oxidation. The workability, split tensile strength, compressive strength, and water absorption are all tested in this study, along with the effects of various fly ash-GGBS ratios and TiO_2 doses. An evaluation of the self-cleaning capability is done by measuring the degradation of specified surface pollutants or stains under regulated light exposure. The study's overarching objective is to identify the optimal combination of fly ash, GGBS, alkaline activator, and TiO_2 for improving the surface-cleaning capability and structural performance of concrete. Potential benefits of the proposed geopolymer self-cleaning concrete include reduced usage of conventional Portland cement, increased durability, utilization of industrial waste, and promotion of low-maintenance, environmentally friendly construction practices. This paper discusses geopolymer self-cleaning concrete and provides a concise overview of the topic. The self-cleaning property of the photocatalytic concrete is determined by observing the discoloration of RhB (Rhoda mine dye) under ultraviolet light. This test is widely recognized as a standard for self-cleaning cementitious materials. The results will shed light on the feasibility of alternatives to conventional concrete, and the photocatalytic action will allow the concrete to double as a green self-cleaning agent. This page also provides a general outline of self-cleaning concrete. The major purpose of this research was to determine the pros and cons of incorporating fly ash and GGBS buildup into concrete by comparing its properties to those of the control mix.

Keywords: Geopolymer Concrete, Self Cleaning Concrete, Green Concrete, Photocatalytic action, Compressive Strength, Tensile Strength, Flexural Strength.

1. Introduction -

When it comes to building materials, concrete is by far the most common and important choice. A combination of water, aggregate, and cement, it is a composite material. To produce the required physical qualities of the finished product, it is common practice to integrate various additives and reinforcements. The combination of these ingredients produces a malleable liquid mass. With the passage of time, the cement solidifies into a matrix that binds the other components, creating a durable stone-like material with many uses.

In order to eliminate biological contaminants, self-cleaning concrete uses ultraviolet light as an energy source. Because of this, contaminants are able to decompose more quickly through the natural oxidation process. Keeping surfaces clean and helping to create a healthier atmosphere are the key benefits of self-cleaning concrete. One important way to lessen air pollution is by using photocatalytic materials. These materials absorb sunlight's UV rays and produce hydroxyl radicals and superoxide anions. These radicals can then interact with pollution molecules, such as NO_x , and convert them into less dangerous chemicals. Areas experiencing high levels of air pollution may find this function particularly useful. Water and air purification, self-cleaning capabilities, and antibacterial effects are some of the features of photocatalysts.

Fortunately, there is an eco-friendly solution to this problem: self-cleaning geopolymer concretes. They are inexpensive, long-lasting, and sustainable, and they reduce CO_2 emissions, among other significant environmental benefits. Because of its special composition, geopolymer cement can resist both high temperatures and acids and salts. Photocatalytic concrete, or self-cleaning concrete, maintains its color and surface cleanliness even in polluted environments and industrial zones. For its inherent ability to keep itself clean, this type of concrete is often called "green concrete."

Constituents of Geo Polymer Concrete -

- Pulverized fuel ash is a byproduct of coal combustion in thermal generating facilities. It contains a lot of silica and alumina and can be used as a cement substitute in concrete, which reduces the environmental impact.
- Ground granulated blast furnace slag, or B. GGBS, is a fine powder that comes from the iron and steel industry. A glassy, granular substance made of silicates and alumina, GGBFS is one way to describe it.
- Composites - geo-polymer concrete makes use of ordinary fine and coarse particles of standard sizes.
- Silicates and hydroxides of sodium and potassium are used in basic solutions. By reacting with silica and alumina from minerals like fly ash and GGBS, these alkaline solutions can produce a binder material that increases the strength of concrete.

Benefits:

Geo polymer concrete offers the subsequent benefits.

- Fully eradicates the necessity for Portland cement, thereby diminishing CO₂ emissions.
- Reduces pollutants and maintains sustainability
- Reduced deformation and little contraction when drying
- Decreases permeability and improves longevity.
- Seventhly, resistant to blasts, seismic activity, and fire.

Drawbacks:

Several drawbacks of GPC are enumerated below.

- Requires careful management due to the involvement of sodium hydroxide, which may pose risks to human safety.
- Restricted to the utilization of precast units.
- Absence of consistency

FLY ASH - The use of fly ash has been vital in civil engineering as a result of its environmental and economic benefits (Ravina and Mehta, 1986; Matković, 1990). Cement FA can only replace a certain amount of cement due to the high levels of free lime in the ash. Factors that influence FA's reactivity include its chemical composition, glassy phase content, specific surface area (SSA), burning temperature (coal or lignite), and phase composition (Matković, 1990). Tillman et al. (2012) states that FA is a chemical with pozzolanic properties. Material is considered "pozzolanic" if it produces insoluble cementitious compounds when combined with lime and water, even though it has minimal cementing action when used alone (Montgomery et al., 1981).

Cement and concrete sometimes include FA, or pulverized fuel ash, a mineral that is a byproduct of power stations that burn coal. The layout of a conventional coal-fired power plant is shown in Fig. 1. The combustible elements, namely carbon, hydrogen, and oxygen, in the coal, when compressed and driven into the furnace's burning zone, reach temperatures of about 1500 °C (2700 °F). Sublime liquid droplets are formed when non-combustible minerals including gypsum, quartz, calcite, pyrite, feldspar, clay minerals, and many more reach this temperature. The rapid cooling of the droplets carried by the exhaust gasses from the burning zone causes the formation of small spherical glassy particles. Mechanical and electrical precipitators, as well as baghouses, are used to remove solid particles from flue gasses. Ash "fly" away from the furnace with the flue gasses; this phenomenon is called FA (Thomas, 2013). Many variables influence FA properties, including coal kind, burning conditions, and collecting method (McCarthy and Dyer, 2019). Despite FA's reaction potentials and its application as a pozzolanic element having been discovered in early 1914, it wasn't until 1937 that a substantial study on FA's use in concrete was published in the US (McCarthy and Dyer, 2019; Halstead). Both the mechanical and durability properties of concrete can be improved by using FA instead of traditional cement (Montgomery et al., 1981; Filho et al., 2013; Montgomery et al., 1981; Montgomery et al., 1981). Depending on the use, FA characteristics, specification limits, geographic location, and climate, the amount of FA added to concrete has traditionally varied from 15 to 25% by mass of the cementitious material component (Thomas, 2007). In extremely rare cases, Marceau et al. (2002) found that concrete with as much as 80% FA might be successfully placed. Two types of FAs are utilized in concrete, as per ASTM standards: class F and class C. Bituminous coal combustion produces the class F FA. Lime or cement are required to activate the glassy substance. The combustion of lignite and subbituminous coal produces Class C FA. It has more calcium than class F FA. According to McCarthy and Dyer (2019) and Marceau et al. (2002), concrete with class C FA increases in strength at a far higher rate than class F FA concrete. Both new and old concrete can benefit from FA's low cost, as it enhances workability, strength, and drying shrinkage. Furthermore, FA, a waste product from industries, can be used in concrete to eliminate the need for storage and disposal (Atis, 2003).

GGBS - Grinding granulated blast furnace slag, or GGBS, is a cementitious material that is produced as a waste product in the iron and steel industry. Supplemental cementitious materials (SCMs) like these are common in concrete and can stand in for Ordinary Portland Cement (OPC) to some extent. The GGBS is made from the molten slag that is generated in an iron blast furnace. When molten blast furnace slag is rapidly cooled, usually with water,

it becomes granulated, a glassy, granular material. This material is dried and ground into GGBS. GGBS is highly useful in many different types of concrete, including geopolymer concrete, underground structures, maritime structures, mass concrete, and high-performance concrete.

To make iron, a blast furnace takes limestone, coke, and iron ore. When iron ore impurities combine with fluxing materials at high temperatures, molten slag is formed.

Basically, what happens is:

Blast furnace producing molten iron and slag from coke, limestone, and iron ore.

The molten slag is rapidly cooled with water after being extracted from the iron melt. Because it prevents crystallization, fast cooling results in a structure that is mostly amorphous or glassy.

Steps in manufacturing –

- Production of molten slag: During the production of iron, slag is created as a byproduct.
Quick cooling/granulation: Water is used to quickly cool the molten slag.
Drying: To get rid of extra moisture, the granulated slag is dried.
- Grinding: To create a fine powder, the dried granulated slag is processed in an appropriate grinding mill.
- Storage: The final GGBS is transported and kept in silos for usage in concrete and cement.

GGBS is especially crucial for geopolymer and alkali-activated concrete. GGBS and other aluminosilicate materials can be used as key precursors in geopolymer systems, in contrast to traditional concrete. For instance:

Alkali-Activated/Geopolymer Binder: GGBS + Fly Ash + Alkaline Activator

Typical alkaline activators consist of: NaOH, or sodium hydroxide

Fly ash typically adds substantial amounts of silica and alumina, whereas sodium silicate (Na_2SiO_3) GGBS contributes significant amounts of calcium.

This combination can offer:

- Quicker development of strength
- Better early-life strength in comparison to systems with high fly ash
- The microstructure is dense.
- Less Portland cement is needed

An example of a typical conceptual system is:

Geopolymer Self-Cleaning Concrete: GGBS + Fly Ash + Alkaline Activator + Aggregates + Self-Cleaning Agent

GGBS mostly contributes to the geopolymer/alkali-activated binder system, but if the self-cleaning mechanism is based on a photocatalyst like titanium dioxide (TiO_2), the photocatalyst is in charge of photocatalytic processes under appropriate light conditions.

Self-Cleaning Concrete - Photocatalytic or self-cleaning concrete is inexpensive, as the name implies. The term implies revolutionary ideas, even though some of us think it's unachievable. But it's doable right now, and many other countries still utilize concrete due to all the good it does. In the vast realm of concrete construction, we have the ability to generate fresh ideas. This concrete cleaning process can enhance the anti-aging properties of concrete while also creating a visually pleasing environment. On the other hand, this type of concrete produces indoor air purification, which helps to ease health issues. Breathing difficulties can be alleviated with time. Protecting concrete is never a priority for customers, but we may work toward this goal by developing self-cleaning technology that uses photocatalysts to clean the concrete. Because of their positive effect on concrete's reactivity, photocatalysts are the ideal filters for this material. Since the reaction has no effect on the cement, you may simply spray it off with water; doing so will not harm the cement or alter its binding properties. Among the remarkable environmental advantages of clean buildings is the potential for air that is less polluted.

Photo catalyst - A wide variety of compounds can act as photocatalysts. Some research on the effects of photocatalysts in cementitious materials has shown this to be true. Using nanoparticles as a photocatalyst improves the performance of the cement's properties. Cement paste can benefit from the addition of nanoparticles, which can either partially or completely replace the cement. In their role as void fillers, these scattered nanoparticles hasten hydration and enhance their tendency to aggregate when mixed. Nanotubes made of carbon, silicon dioxide, zinc oxide, titania, or titanium dioxide, and aluminum oxide are the nanoparticles most commonly used in cement products. Adding nano-silica to the cement paste changed the mechanical properties of the items, according to the research. Because of its strong catalytic activity and chemical durability, TiO_2 nanoparticles are typically added with photocatalytic activity, according to a few studies. When it comes to chloride penetration, concrete having nano- TiO_2 is more resistant than concrete containing nano- SiO_2 . Reason being, nanoparticle presence refines pore structure, leading to less chloride penetration. Including nano- TiO_2 enhances geopolymer synthesis and leads to a microstructure that is more compact and has fewer fissures. The compressive strength of the modified cement can be enhanced by including additional nano- TiO_2 . Adding TiO_2 to concrete sample has been the subject of multiple studies. One naturally occurring molecule that can break down gaseous contaminants when exposed to sunshine is titanium dioxide (TiO_2). There have been reports that nano titanium

dioxide (nano-TiO₂) can enhance the mechanical and durability qualities of concrete. In addition to improving mechanical and durability qualities, ZnO shows improved effectiveness in the photocatalytic destruction of some reactive dyes in aqueous solutions.

Geo Polymer Concrete - Geographical polymers are an example of inorganic polymers. An alkaline liquid reacting with silicon (Si) and aluminum (Al) as geological source materials or with by-product materials like fly ash and rice husk ash was proposed by Joseph Davidovits (1978) as a means to produce binders. We call these binders "geo polymer" since the precursors come from the earth and the chemical reaction involves a polymerization process. The rising importance of geopolymer concrete is directly proportional to the fact that carbon emissions and the subsequent threat of climate change have surpassed all other global concerns. When making one metric ton of cement, one metric ton of carbon dioxide is discharged into the atmosphere. Fly ash is being promoted as a building material by numerous nations through the provision of carbon credits. This will promote the utilization of fly ash waste, a massive disposal issue on a global scale, while simultaneously reducing cement output and carbon dioxide emissions. Because thermal generating stations are present in almost every Indian state, fly ash is easily accessible. Potassium or sodium are common bases for the soluble alkali metals used to create these acidic liquids. Most alkaline liquids used in geopolymerization are combinations of sodium hydroxide (NaOH) and potassium hydroxide (KOH) with sodium silicate or potassium silicate. Alkaline solutions such as sodium hydroxide and sodium silicates are easily accessible, cheap, and commonly used. This research delves into the topic of geopolymer concrete that is made from heat-cured, low-calcium fly ash. Fly ash with a low calcium content (ASTM Class F) is preferred over fly ash with a high calcium content (ASTM Class C) when choosing a source material.

2. OBJECTIVES OF THE STUDY

This research facilitates the analysis of heavily polluted areas in India and evaluates the relationship between pollutant levels. Furthermore, it identifies areas where photocatalytic concrete infrastructure can demonstrate optimal efficacy according to the trial results. To elucidate the impact of environmental factors, especially temperature, on the photocatalytic degradation of pollutants to establish a relationship between photocatalytic efficiency and seasonal climate. The amount of by-product or waste substitution significantly influenced the characteristics of concrete. Waste resources possess considerable potential for the production of eco-friendly concrete. This research aims to ascertain the characteristics of concrete by including supplemental cementitious materials such as GGBS and Fly Ash as substitutes for cement in the concrete mix.

The incorporation of titanium dioxide into concrete has shown efficacy in degrading pollutants, including nitrogen oxides, upon exposure to sunlight. This photocatalytic mechanism efficiently eliminates surface impurities from concrete, resulting in a cleaner and more sustainable ecosystem. The findings of this research indicate that using extra cementitious materials and titanium dioxide in concrete can contribute to more environmentally friendly concrete and enhanced sustainability, along with financial advantages. Additional investigation and advancement in this area may result in the widespread adoption of geo polymer self-cleaning concrete as a means to enhance the longevity and upkeep of infrastructure.

3. Literature Review –

Concrete is a commonly utilized building material; yet, it can gather dust, grime, and various contaminants that result in degradation and diminished visual attractiveness. Self-cleaning geopolymer concrete represents a viable alternative capable of self-purification via a photocatalytic process. Numerous investigations have been conducted to tackle the aforementioned environmental issues. The alternative pozzolanic substances comprise fly ash, silica fume, ground granulated blast furnace slag (GGBFS), and rice husk ash. French academic Davidovits was the initial proponent of the term "Geo-polymer". Geo-polymer concrete serves as a substitute for traditional concrete, employing source minerals abundant in silica and alumina to provide binding qualities instead of cement. The adhesive characteristic is attained through the interaction of alkaline solutions with the pozzolan source material. The interaction between the precursor substance and alkaline solution produces a gel referred to as aluminosilicate. The gel produced binds the particles and additional components in concrete to create geo-polymer concrete. One method to attain self-cleaning concrete involves substituting a fraction of the cement with photocatalytic substances, including titanium dioxide (TiO₂). This literature study will encapsulate the results of many experimental investigations about the application of supplemental cementitious materials and TiO₂ in self-cleaning geopolymer concrete.

Md Toriqe Islam Et.al Because of its low environmental impact, geopolymer concrete is quickly becoming a favorite among academics in this field. But cracks in OPC and geopolymer concrete buildings can shorten their lifespan because reinforcement is exposed to outside forces, which causes concrete to deteriorate. In response to these difficulties, concrete's inherent self-healing capabilities provide a fresh strategy for repairing damage and cutting down on maintenance costs. The efficacy of several restoration techniques for geopolymer concrete, including crystalline additives, fibers, microbes, and enzymes, are detailed in this paper. The self-repairing efficacy of different healing agents is primarily examined in this research through the examination of geopolymer formulations. Concurrent studies on OPC systems are conducted to facilitate a comparative understanding of the fundamental healing mechanisms. Many healing agents, including crystalline additives and enzyme-driven systems, were originally developed for OPC-based concrete but have not been adequately studied in geopolymers. Crystalline admixture did not aid in fracture healing in the geopolymer matrix, according to recent studies, unless an additional 10% Ca(OH)₂ was added to the binder. The combination of natural fibers, bacteria, and fibers injected with therapeutic compounds greatly improved the healing efficacy, leading to a crack width of up to 800 µm. The compressive, split tensile, and flexural strengths of the concrete are enhanced by adding the right amount of various healing ingredients. The optimal crystalline additive to binder weight ratios ranged from 1% to 1.5 percent, and the bacterial concentration was found to be between 10⁵ and 10⁷ cells/mL. In addition, the evaluation details the practical applications and limitations of various treatment agents. This project aims to offer a long-term solution for robust infrastructure by combining geopolymer concrete with appropriate healing agents.

According to Prinya Chindaprasirt, geopolymers are a novel cement-free binding agent that has been extensively studied as a Portland cement alternative. But, just like regular concrete, geopolymers can soak up water. In order to prevent the fly ash geopolymer from absorbing moisture, this study presents a method for creating a surface that is both superhydrophobic and self-cleaning. A hydrophobic surface was achieved by inserting dispersed microparticles of polytetrafluoroethylene (PTFE) or calcium stearate (CS) into a polydimethylsiloxane (PDMS) solution and applying a composite coating using a dip-coating process. To further improve surface roughness and reduce material costs, fly ash was added to the PTFE and CS microparticles. Coating with CS microparticles created a hydrophobic surface with a 140° contact angle, according to the experimental results, whereas coating with PTFE microparticles made the surface superhydrophobic, with a 159° contact angle. A higher contact angle and a lower sliding angle were the results of the increased surface roughness brought about by the addition of fly ash. The surface that was coated with PTFE and fly ash had a contact angle of 153° and a sliding angle of 8.7° . In an experiment, water droplets were used to remove dust off a surface, demonstrating the cleaning method. The assessed coating showed signs of being waterproof and self-cleaning, which might make building materials more environmentally friendly.

An environmentally preferable substitute for traditional Portland cement concrete, Geopolymer concrete is a viable option, according to T. Vamsi Nagaraju¹. Industrial byproducts' pozzolanic properties also influence their price, as do rising carbon levies on carbon emissions and energy-intensive materials like lime and cement. The compressive strength of geopolymer mortar, the flexural strength of geopolymer concrete, and both are evaluated in this work. An analytical method was used to evaluate the strength of the geopolymer mortar, and data from the geopolymer concrete was used to study sustainability metrics and strength. Based on experimental datasets of geopolymer mortar mixtures with different precursor, alkali-activator, Si/Al, and Na/Al ratios, models for compressive strength were developed using artificial neural networks (ANNs), multi-linear regression (MLR) analysis, and swarm-assisted linear regression. The cost-effectiveness, energy efficiency, and environmental efficiency of geopolymer concrete compositions with different precursors were examined in order to determine their strength and sustainability features. What makes this method stand out is that it improves sustainable high-performance concrete without making hasty assumptions about its causes. This study used extensive experimental testing to determine the ideal ratio of silica fume, ground granulated blast furnace slag (GGBS), and rice husk ash (RHA) for use in geopolymer concrete. To better understand the geopolymer matrix's microstructure, a scanning electron microscopy study was carried out. The future role of RHA is explained in detail in the discourse portion that follows. In all of its current uses, this environmentally friendly high-performance concrete with RHA has the ability to replace conventional concrete.

1Rakesh Kumar, Professor; 2Chandgude, Ms. Gauri; 3Gond, Mr. Pravin; 4Chandgude, Mr. "A Review on Titanium Dioxide - A Study of Self-Cleaning Concrete" by Aditya Shete and Ms. Siddhika Jadhav, published in the 2023 International Journal of Construction and Related Technologies, volume 11, issue 5, may 2023, with the ISSN number 2320-2882, lays the groundwork for building technology. However, a lot of carbon dioxide (CO₂) is released into the air during cement production, which makes climate change worse. This led to the development of eco-friendly construction materials such as photo catalytic concrete. In a revolutionary shift away from Portland cement, photocatalytic concrete uses a binder that is easier on the environment. To improve the cement's mechanical properties, this new invention adds nanoparticles, such as nano clay, to the mix. Modern concrete mixes include innovative additives that naturally remove dust and debris from the building site. The incorporation of photocatalytic chemicals, such as titanium dioxide (TiO₂), is responsible for concrete's self-cleaning properties. These photocatalysts, when added to self-cleaning concrete, would speed up the breakdown of organic materials by exposing them to ultraviolet (UV) radiation. This allows for the preservation of structural exterior hygiene while simultaneously reducing air contamination. A concise analysis of self-cleaning concrete is presented in this article.

Hemn Unis Ahmed et al have lately studied the micro and macro characteristics of geopolymer concrete (GPC) in an effort to find a suitable replacement for Portland cement concrete (PCC). Modern cementitious materials called geopolymers (GP) may one day completely replace organic polymer composites. When compared to regular Portland cement (OPC), geopolymer composites (GC) use less energy and leave less of a carbon imprint. Material qualities and the performance of reinforced concrete (RC) structural components are the main concerns in the construction industry. In light of that, this review paper will take a look at a number of important material metrics, such as new features, modulus of elasticity, flexural strength, splitting tensile strength, compressive strength, and proof of the structural behavior of GPC beams. According to the findings, GPC outperforms conventional concrete composites in terms of fresh and mechanical properties. Not only that, but GPC may be used to safely build GPC members according to their strength capacities and predetermined rules of behavior. However, in order to incorporate more thorough and cost-effective design methodologies for the potential use of GPC in large field applications, further research is needed.

The impact of TiO₂ incorporation on concrete's self-cleaning characteristics was investigated experimentally by Prathamesh R. Ingole et al. in their 2022 article "Self-Cleaning Concrete: The Future" published in the International Journal of Scientific Research & Engineering Trends, volume 8, issue 2, March–April, 2022, ISSN (Online): 2395–5669. The researchers built concrete samples with varying amounts of TiO₂ and used a photocatalytic degradation test to determine how well the samples cleaned themselves. The results showed that the self-cleaning capabilities of concrete were improved by adding TiO₂.

Research on self-cleaning concrete using titanium dioxide was published in the 2021 Journal of Engineering Technology and Innovation (JETIR) in June 2021 (ISSN: 2349-5162) and was authored by Hritik S. Behare, Aditya N. Bhosale, Jeevan C. Kadale, Sagar B. Kale, and Dinesh W. Gawatre. But cement production releases a lot of carbon dioxide (CO₂) into the air, which adds to the worsening climate crisis. The result is photocatalytic concrete, a new eco-friendly alternative to traditional construction materials. One modern alternative to cement, photocatalytic concrete uses an eco-friendly binder to create modern building materials. This method improved the cement paste's mechanical properties by adding nanoparticles, such as nano clay. Engineers have also made the concrete substances so that they can clean themselves as needed. Photocatalytic chemicals, such as titanium dioxide (TiO₂), activate the self-cleaning properties of the concrete. When exposed to ultraviolet (UV) light, self-cleaning concrete with photocatalytic capabilities will break

down organic particles more quickly. This has the potential to reduce ambient air pollution while simultaneously protecting the exteriors of the buildings from dirt and grime. This paper provides a concise analysis of self-cleaning concrete.

The article "Fly Ash Based Self-Cleaning Geopolymer Concrete Using Nanotechnology —A Review" by S.K. Maniarsan, V. Santhosh Kumar, and P. Chandrasekaran was published in the International Journal of Scientific and Technology Research (ISSN: 2277-8616), volume 9, issue 02 (February 2020). Significant amounts of carbon dioxide (CO₂) are released into the atmosphere during cement production, which exacerbates global warming. This led to the creation of geopolymer concrete, a practical and environmentally friendly construction material. Geo polymer concrete is an innovative alternative to Portland cement that aspires to be an eco-friendly binding agent in building materials. Geopolymer concrete's mechanical properties are enhanced by adding nanoparticles to the cement matrix. Concrete has evolved to serve as a self-cleaning material in construction due to its unique qualities. The incorporation of photocatalytic material, particularly Titania (TiO₂), into self-cleaning concrete gives it promising characteristics. When exposed to ultraviolet light, such as that from the sun, the photocatalysts in self-cleaning concrete will begin to decompose organic materials. Thus, rust is not present. It is possible to reduce environmental pollution while maintaining the TiO₂ surfaces. Based on the research of multiple writers, this review article delves into the workings, properties, and uses of geopolymer and Titania, while also discussing the potential health risks linked with these substances. The purpose of this review article is to point the way toward more research on geopolymer concrete that uses nanotechnology for self-cleaning.

In the International Research Journal of Engineering and Technology (IRJET), Anju Raj discusses the behavior of self-cleaning concrete using various photocatalysts. The article may be found online at this link: e-ISSN: 2395-0056. An approach to reducing air pollutants such as NO_x, SO₂, CO₂, and VOCs that are produced by industrial processes, urban areas, and vehicle activity is self-cleaning concrete. To reduce air pollution, photocatalytic chemicals are mixed into regular concrete for city buildings and road surfaces. Both titanium dioxide (TiO₂) and zinc oxide (ZnO) can be used as photocatalytic substances. Concrete can have titanium dioxide (TiO₂) or zinc oxide (ZnO) added to it at concentrations of 0, 0.5, 1, or 1.5% by weight of cement. Concrete cubes that had been cured for 28 days were tested for their compressive strength. A solution of magnesium sulfate (MgSO₄) and sodium chloride (NaCl) was used to evaluate the self-cleaning concrete's durability. Rhodamine dye (RhB) discolouration under UV light is used to assess the self-cleaning property of photocatalytic concrete. Light, the standard test for cement-based compounds that self-purify.

The effectiveness of self-cleaning concrete was examined in a study by T Vignesh et al. (2018) in the International Journal of Engineering Technology, volume 7, issue 3, page 860, with the DOI 10.14419/ijet.v7i3.12.16551. The researchers replaced cement with TiO₂ nanoparticles to create the material. Based on the results, it seems that TiO₂ can boost the self-cleaning properties of concrete, since the TiO₂-enhanced concrete was more effective at cleaning itself than regular concrete.

A study conducted by Oyeibisi et al. (2018) investigated the activation of corncob ash and ground granulated blast furnace slag with sodium hydroxide and sodium silicate solutions. The researchers made geo-polymer concrete using this mixture and found that it had higher compressive strength than Portland cement concrete when treated with 12 M sodium hydroxide. For optimal strength, it is recommended to use 60% crushed granulated blast furnace slag and 40% corncob ash as substitutes for Portland cement concrete.

While keeping the ratio of alkaline liquid to fly ash constant, Lăzărescu A. et al. (2018) varied the ratio of Na₂SiO₃ to NaOH solution and the concentration of NaOH solution to determine which factors affected the mechanical properties of fly ash-based geopolymer concrete. The results showed that compressive strength was significantly improved with increasing sodium silicate solution content.

Article published by IOP Publishing: "Self-cleaning geopolymer concrete - A review" by Siti Norsaffirah Zailan, Norsuria Mahmed, Mohd Mustafa Al Bakri Abdullah, and Andrei Victor Sandu, presented at the International Conference on Innovative Research 2016 - ICIR Euroinvent 2016. No. 133 (2016) 012026 in the series Materials Science and Engineering. Construction technology mostly makes use of concrete, as stated in doi:10.1088/1757-899X/133/1/012026. However, a significant amount of carbon dioxide (CO₂) is released into the atmosphere during cement production, which adds to the worsening of global warming. Because of this, geo polymer concrete, an environmentally beneficial building material, was born. An innovative alternative to traditional Portland cement, geo polymer concrete uses a binder that is easier on the environment. One new development in cement technology is the addition of nano-particles, such as nano clay, to improve the material's mechanical properties. Additionally, the concrete substances can be used as self-cleaning construction materials thanks to their engineering. Titania (TiO₂) and zinc oxide (ZnO) are two examples of photocatalytic chemicals that can trigger the self-cleaning properties of concrete. Ultraviolet (UV) light will activate photocatalysts in self-cleaning concrete, speeding up the decomposition of organic particles. Soil and air pollution levels can be reduced and building exteriors can be kept clean. A brief introduction to self-cleaning concrete is given in this document.

The extensive research on geopolymer concrete made from fly ash is detailed in an article by B. Vijaya Rangan titled "Fly Ash-Based Geo Polymer Concrete" published in the Australian Journal of Structural Engineering in January 2005 (DOI: 10.1080/13287982.2005.11464946). Notable factors influencing the properties of fresh and cured geo polymer concrete are identified. After that, you'll find experimental evidence of the geopolymer concrete's varied short- and long-term properties. This paper shows how geopolymer concrete is used in the building industry and details the results of tests done on large reinforced geopolymer concrete components. Also covered are the recent uses of geopolymer concrete in precast building and the financial benefits of this material.

4. Conclusion –

According to previous studies, self-cleaning concrete that contains additional cementitious elements and titanium dioxide has the potential to reduce costs and increase infrastructure durability. The concrete's inherent self-cleaning properties keep the surface free of grime and other impurities that could otherwise cause discoloration and degradation. The various issues with both regular concrete and geo-polymer self-cleaning concrete were the focus of this research. Concrete mixtures are improved and a more feasible disposal option is provided. More and more advancements in building materials are possible as the need for them rises every day. Concrete mixes that include cementitious additives are more versatile, easier to work with, and help preserve natural resources for use in the future, all of which are important in the construction industry.

With its photocatalytic properties, concrete can clean and cleanse itself, as well as purify the air around it. Incorporating photocatalysts into regular concrete results in photocatalytic concrete; the best photocatalyst to use in this case is titanium dioxide (TiO₂). When exposed to light with an intensity greater than the photocatalyst's band gap, a photocatalytic reaction can take place. By interacting with contaminants, the created very reactive hydroxyl radicals can release harmless substances like carbon dioxide and water. Air purification and natural cleansing are achieved when the disintegrating toxins are carried away by the wind or precipitation. There is great promise for the use of photocatalytic concrete in the areas of odor removal, energy conservation, pollutant degradation, and sterilization.

5. References -

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