AN INVESTIGATION ON THE BINDING AND STRENGTH CHARACTERISTICS OF FLY ASH-BASED GEOPOLYMER CONCRETE

Bandari Dinesh kumar[1], Dr. G Dineshkumar[2], Riyaz Syed[2]
[1]M.Tech Scholar, [2]Associate Professor, [3]Assistant Professor
Department of Civil Engineering, Vaagdevi College of Engineering
Bollikunta, Waranagal, Telangana-506002
Corresponding Email id: dinesh62892@gmail.com

ABSTRACT

In light of their possible environmental impact, there is an urgent need to decrease cement use and promote the utilization of a range of industrial wastes. Alkaline substances can activate aluminosilicate-rich industrial waste to create geopolymer concrete, a cement-free concrete type. Using fly ash as a binder material would significantly contribute to the green revolution, as it is widely known to contain high quantities of aluminosilicates. Therefore, this research aims to create geopolymer concrete using fly ash as the binder and alkaline activators such as sodium hydroxide (NaOH) and sodium silicates (Na2SiO3). Mechanical property investigations determine the compressive, splitting tensile, and flexural strengths, as well as durability qualities measured by water absorption, sulfate resistance, acid resistance, and alkalinity. This is in line with the observed trend in regular concrete, where the strength of the material falls as the water-to-cement ratio increases.

Keywords:durability, mechanical qualities, geopolymer concrete, and industrial waste.

INTRODUCTION

Airborne CO2 levels have risen dramatically due to human activities such as burning fossil fuels, making cement, cutting down trees, and other development projects. Atmospheric CO2 levels are now abnormally high due to emissions caused by humans. Because these man-made sources account for 87% of emissions, they are mostly responsible for upsetting the atmospheric CO2 balance. Rapid urbanization and industrialization have an effect on the construction industry and, by implication, on consumer spending. An increase in cement consumption results in a significant release of carbon dioxide into the atmosphere. The chemical processes and fuel used in cement production result in the emission of approximately one metric ton of carbon dioxide gas into the environment during its manufacturing (Neville, 2014). In 2015, the USGS reported that cement production was 4.2 billion metric tons, with a yearly growth rate of 3-4%. The IPCC reports that, among all non-energy industrial processes, cement production is the leading cause of carbon dioxide emissions worldwide. The Cement Sustainability Initiative (CSI) reports that almost 5% of all industrial and energy-related CO_2 emissions occur during cement manufacture around the world. Figure 1 shows the percentage contributions of the various tasks. But because of the aesthetic value it lends to constructions, cement is a vital component of most building materials. Consequently, it may be prudent to look into alternatives to OPC concrete. To lessen its impact on the environment, "geopolymer concrete" makes use of aluminosilicate-rich industrial waste materials including slag, fly ash, and red mud. This helps with material manufacturing, disposal, and carbon emissions. The Origins of Geopolymer Concrete

and Related Complementary Materials.

According to the Geopolymer Institute (2010), French physicist Joseph Davidovits started researching geopolymer concrete in 1978. The last ten or so years have seen a heavy focus on research on geopolymer concrete and its performance evaluation, a stark contrast to the nearly non-existent research in this area during the preceding twenty years. Geopolymer concrete significantly reduces greenhouse gas emissions compared to regular concrete, a factor that underscores the public's growing concern about global warming and the necessity for more energy efficiency (Silva et al., 2007).

Aluminosilicates can be found in abundance in fly ash, ground granulated blast furnace slag, red mud, copper and hematite mine tailings, silica fume, metakaolin, and numerous other industrial by-products and natural raw materials (Gorhan et al., 2013; Aydinetal., 2012; Yusufetal., 2014; He et al., 2013; Vukcevic et al., 2013; Ahmari et al., 2012; Manjunath et al., 2011; Pelisser et al., 2013). The resulting structure is as strong as, if not stronger than, conventional concrete, having gone through a transformation from amorphous to semi-crystalline. "Ion" refers to the inorganic polymerization process that occurs when a source material, typically composed of rocks, combines with an alkaline activator (Davidovits, 200). Consequently, geopolymers make it easier for businesses to make the most of their resources. The by-products of rialConcrete aid in pollution management and reduce the risks associated with incorrect trash disposal.

Current State of Affairs Concerning the Application of Fly Ash Moss Ash

More than 70% of India's power comes from thermal power stations that burn coal, and the country ranks fourth in the world for coal fly ash production. Sahuetal (2009) classifies Indian coal as low grade due to its high ash percentage of 30-45%, which generates a significant amount of fly ash. The ASTM ACI Committee 116 defines flyash, a finely divided waste product of coal combustion, as the primary component of fluegasses, which the boiler expels. Typically, fly ash particles are round and can range in size from fifty micrometers to one hundred micrometers.

According to CEA (2015), India actually uses about 60.77 percent of the 180 million tons of fly ash it produces annually. On the other hand, India produces 850 million tons of fly ash annually, of which only 25 to 30 percent find actual use (Yao et al., 2015). EvenDespite fly ash being utilized in a variety of applications such as highways, flyovers, distemper, cement, concrete, minefilling, ash drying, floodplain restoration, and agriculture, only approximately 60.77 percent of it ends up in these areThe disposal of unutilized fly ash raises significant environmental concerns. Ashoka et al. (2005) state that fly ash from thermal power stations that burn coal is one of the primary causes of environmental

contamination. Among the many issues that this ash exacerbates are land degradation, health hazards, and contamination of the air, soil, and water. Using geopolymer concrete, which consists of fly ash instead of cement, is one potential approach (Palamoetal., 1999). In cases where

The total oxide content of this fly ash type is 70% or higher (SiO_2, Al_2O_3, Fe_2O_3), with a reactive CaO component of 10% or below. Class C fly ash is defined as fly ash with a reactive CaO concentration greater than 10% and a total major oxide content superior to 50%. ASTM C618 criteria classify fly ash classes C and F based on their chemical qualities, as presented in Table 1.1 below.

The potential integration of industrial waste into biopolymers carries significant consequences.

For storage, it needs large tracts of arable land. Acquisition of land is becoming more and more of a challenge these days. The building and upkeep of the storage space also incur substantial costs. Additionally, fly ash contaminates groundwater at adjacent properties because of its leaching behavior. PendeconTalk (2009) states that an ordinary residence can cover its solid waste for 455 days with one tonne of fly ash utilization. Furthermore, we have incorporated a fundamental, logical blend.

We used the suggested mix design to create a variety of geopolymer concretes, utilizing different binder material combinations. We subsequently tested these concretes for mechanical strength, durability, and corrosion resistance. We have conducted a microstructure analysis to further investigate the parameters influencing the behavior of the geopolymer concrete.

LITERATUREREVIEW

This chapter reviews previous research on geopolymers and granite powder and gives a brief introduction to the chemistry and vocabulary related to geopolymers. Also included are the methods for studying geopolymers, with citations to Hardjito and Rangan (2005).

Geopolymers: A Chemistry and Terminology Study

Following his work with silico-aluminate components, Davidovits suggested the name "poly(sialate)" to describe geopolymers (Davidovits, 1988; van Jaarsveld et al., 2002a).

Polymeric structures that can form rings and chains are characterized by sialates, which are silicon-oxo-aluminates. Silicon (Si) and aluminum (Al) coordinate with oxygen to form the tetrahedral arrangement of these structures. You can produce amorphous or semi-crystalline structures.

You can conceptualize poly (sialates) as follows in practical terms:

The poly(sialate) type is one of three types of polysialates described by Davidovits (1988b). Davidovits (1988b) describes it as follows: -Si-O-Al-O-Si-O is the formula for poly(sialate-siloxo). -Si-O-Al-O-Si-O-Si-O is the third type of poly(sialate-disiloxo). Figure 3 displays the polymeric structures, while Figure 2 illustrates the basic forms of polysialates.

The process of geopolymerization creates polymeric Si-O-Al linkages by reacting alumina-silicate oxides ($SiO2$, $Al2O3$) with alkali polysilicates chemically. Sodium or potassium silicate, often obtained from the chemical industry or produced as a by-product of ferro-silicon metallurgy in the form of fine silica powder, composes poly-silicates. The empirical equation above illustrates the process of poly-condensation into poly (sialatesiloxo). Instead of relying on the creation of matrix bonds with calcium silicate hydrates (CSHs), as is the case with traditional Portland/pozzolanic cements, geopolymers achieve their strength through the polycondensation of silica and alumina precursors and a high alkali content. The term "alkali-aggregate reaction (AAR)" is notoriously detrimental in concrete, and the terms "alkali-activated cement" and "alkali-activated fly ash" are often used interchangeably.As the mixture cures in the oven, the excess water is evaporated.

These could be naturally occurring minerals with a chemical composition mostly consisting of silicon (Si), aluminum (Al), and oxygen (O), such as kaolinite, clays, micas, andalusite, spinel, etc. (Davidovits, 1988). Fly ash, silica fume, slag, ash from rice husks, red mud, and other by-products could also be utilized as raw materials. Factors such as availability, pricing, application type, and end-user particular demand determine the supply materials for geopolymers. Most often, sodium- or potassium-based soluble alkali metals are the sources of the acidic liquids.

A conceptual model by Duxson et al. (2007) states that the dissolving process initiates the geopolymerization mechanism. Alkaline hydrolysis dissolves the aluminum silicates in the raw materials by converting them into alumina and silicate precursor units through water consumption. Certain reports suggest that the surface dissolving mechanism causes the gel formation during geopolymerization. In the gel solution, different types of silicates, aluminates, and aluminosilicates mix with water to make SiO4 and AlO4 tetrahedral units. Hydroxide molecules of aluminum or silicon form condensation when they form covalent bonds with oxygen atoms and release water. The gel immediately causes the network of monomers to reorient and reorganize, forming three-dimensional aluminosilicate networks.

There are aspects of geopolymer concrete that influence its characteristics.

Many factors affect the properties of geopolymer concrete. These factors include the type and concentration of the alkaline activator, the curing temperature and time, the chemical composition and type of the source material, the water content, the molar Si to Al ratio in both the source material and activator solution, the amount of Si dissolution, the ratio of sodium silicate to sodium hydroxide by mass, the ratio of SiO2 to Na2O, the mixing time, the rest period before curing, and many others.

The activator type plays a crucial role in geopolymerization. According to Palomo et al. (1999), soluble silicates in alkaline solutions have a higher reaction rate than hydroxides. According to Oh et al. (2010), using a combination of NaOH and Na2Sio3 as an alkaline solution increased both the compressive strength and the rate of alkali activation. Hardjito et al. (2005) and Reddy et al. (2010) found that the compressive strength rose as the molarity of the NaOH solution increased. The higher setting rate causes less time for the dissolution of alkali metals from the source material, resulting in more unreacted particles and a decrease in compressive strength (Vukcevic et al., 2013). The process of ion leaching begins when fly ash comes into contact with NaOH. A sodium silicate solution's silicon concentration is another factor that affects concrete's compressive strength.

When it comes to the mechanical strength of GPC, curing time is just as important as curing temperature. The curing temperature and time affect both the rate and magnitude of a chemical reaction (Davidovits, 1999). The strength gain, however, does not last after 24 hours (Hardjito and Rangan 2005). Properly prepared geopolymer concrete mixes can also provide adequate mechanical strength of gpc during regular ambient curing (Manjunath et al. 2011).

The production of geopolymers can begin with any material that has an amorphous form and mostly consists of silicon and aluminum. Due to the fact that a high calcium content might affect the microstructure and impede the polymerization process, low calcium fly ash is typically favored as a source material over high calcium fly ash (Hardjito and Rangan 2005).

Hydroxides, silicate solutions of alkali metals, and water are all examples of alkaline activator solutions. Additionally, this connection allows for the expansion of the water to geopolymer solid ratio. According to Hardjito et al. (2005), the compressive strength of concrete diminishes as the water-to-geopolymer solid ratio increases. According to Van Jaarsveld et al. (2003), the water-to-lyash ratio is an important factor in geopolymer properties. Xu and Deventer (2000) showed that factors such as the percentage of CaO and K2O, the ratio of Si to Al in the source material and the solution, the kind of alkali liquid, and the extent of Si dissolution greatly affect the compressive strength of geopolymers.

Thorkchometal (2009) conducted a study on fly ash-based geopolymer mortars, varying the percentage of Na2O content. The findings demonstrated a direct correlation between the alkalinity loss in the samples and the alkali concentration. Their research revealed that a lower percentage of Na2O led to a faster loss of alkalinity compared to a higher percentage. Researchers Hardjito et al. (2005) looked at the compressive strength of fly ash geopolymer concrete and found that longer mixing times led to less slump, higher final densities, and higher compressive strengths. This strength was unaffected by longer rest times, according to their findings. Resting the specimens for at least one day after casting also boosted their compressive strength, they deduced.

Geopolymer Alkaline Solutions' Source Materials

Davidovits (1988c) has been studying the possibility of creating geopolymers by reacting kaolinite with alkalis (NaOH, KOH) since 1972. Multiple patents detail the technique known as the "SILIFACE Process". Davidovits introduced KANDOXI (Kaolinite, Nacrite, Dickite Oxide), a calcined kaolinite product, in 1999. Davidovits calcined it for six hours at 750°C. Similar to other calcined materials, this caolinite showed better performance in geopolymer synthesis than its natural counterparts.

In their investigations into geopolymer synthesis, Xu and Van Deventer (1999; 2000) investigated many alumina-silicate minerals. They looked at sixteen naturally occurring Si-Al minerals. These minerals had different crystal structures, like ring, sheet, and framework types, and they were from groups like garnet, mica, clay, feldspar, sodalite, and zeolite. Researchers discovered numerous naturally occurring alumina-silicate minerals as potent raw materials for geopolymer production. They found that potassium hydroxide (KOH) produced superior compressive strength and dissolving efficiency when compared to sodium hydroxide (NaOH) for alkaline solutions.

MATERIAL CHARACTERIZATION

Components Examples of geopolymer concrete include the following materials:

The ingredients for the binder are aggregates made of low-calcium fly ash, which are sized at 20 mm, 12.5 mm, and 6.3 mm.

We prepare the sodium hydroxide (NaOH) solution using water, sodium silicate, and an alkaline activator solution.

Fly Ash, Low-Calcium

High concentrations of calcium oxide (CaO) can enhance the self-hardening characteristics of Class C fly ash. Evidence suggests that the amount of calcium in fly ash has a major impact on the rate of strength development and the ultimate compressive strength; in particular, that higher calcium levels result in quicker strength acquisition and higher compressive strength.

However, for the material's binding qualities to be at their best, fly ash should have a low calcium content and other features, such as unburned

The material should have a content of less than 5% and no more than 10% Fe2O3. Reports also suggest that a high concentration of calcium in fly ash alters the microstructure and could impact the polymerization setting rate. Hence, it seems that geopolymers made from low-calcium (Class F) fly ash are better than those made from high-calcium (Class C) fly ashes. The fly ash used in this investigation has an oxide content that may be seen

FineAggregate

This project uses collected sand from the local river at Bhubaneswar as a fine aggregate. Clay, silt, and other organic contaminants are not present. ASTM standards determined the sand's specific gravity and fineness modulus to be 2.6. In the following chapter, you can see the results of the sieve analysis in Table 4.1. The beach is

Zone II compliant.**CoarseAggregate**

This project used coarse aggregate with varying passing sizes—20 mm, 12.5 mm, and 6.3 mm (see figure 8 for details).

Another critical factor in polymerization is the kind of alkaline liquid used. A mixture of sodium hydroxide (NaOH) or potassium hydroxide (KOH) and sodium silicate (Na2SiO3) or potassium silicate (K2SiO3) is the most typical alkaline liquid utilized in geopolymerization. By adding Na2SiO3 to an alkaline NaOH solution, the interaction between the source material and the solution is improved. In general, the NaOH makes minerals dissolve more completely than the KOH (Lee et al. 2004). So, the alkaline solution in this investigation is the one with Na2SiO3 and NaOH (Fig. 9).

Sodium Hydroxide with Sodium Silicate Mixture

With a specific gravity ranging from 1.37 to 1.41, the Na_2SiO_t solution utilized in this work comprises 9.5% Na_2O, 26.5% SiO_2, and 64% water. Depending on the molarity, the specific gravities of the 99% pure NaOH pellets utilized range from 1.28 to 1.38.

Method for Measuring Sodium Hydroxide Solutions

MIXDESIGNDEVELOPMENT

The chosen materials underwent testing in accordance with established standards. We subjected coarse aggregate, fly ash, and fine aggregate to the tests detailed below. We tested trial mixes of geopolymer mortar cubes based on fly ash.

Specific Gravity Test Results for Fly Ash

We used the tried and trusted Le Chatelier method to test the fly ash for specific gravity. The provided table displays the results:

GrainSizeDistributionofFineAggregate

The table below presents the results of the sieve analysis using conventional sieve sets. We considered coarse aggregate that passed through a 20 mm, 12.5 mm, and 6.3 mm sieve when designing the mix for the geopolymer concrete.

Combined Grading of Fine aggregate and Coarse aggregate

The design of the polymer concrete mix adheres to the DIN grading curves. Table 1 shows the aggregate grading curve when both fine and coarse particles are considered. Graph 1 displays the aggregate combined grading curve for the mix design.

Geopolymer Concrete from Industrial Waste: A Proposed Process

Any type of geopolymer concrete that follows the absolute volume technique can benefit from the mix design methodology proposed in this work, which aims to address fly ash-based GPC in a rational way. By adjusting the activator content, the final GPC product's price can be significantly reduced, as the activator solution is the most expensive raw material used to make GPC. This mix design thus fixes the alkaline activator solution to 200 kg/m3. Doing so also allows for more leeway in the design mixtures, which is great from the standpoint of both the strength needed and the desired activator solution. The suggested method's key advantages are its adaptability to different activator solutions to fly ash ratios and its ability to estimate the likely strength that can be reached for different ratios. The formula for determining the binder content is the ratio of activator solution to fly ash, which stems from the activator solution's content.

The suggested mix design process additionally considers the material's volume and specific gravity. So, the combined aggregating grading curve is used to establish the individual aggregate content. The study also addresses improvements to the practicality of GPC.

EXPERIMENTAL PROCEDURE

Making a Sodium Hydroxide Solution for Use in Making Geopolymer Concrete

We dissolved sodium hydroxide (NaOH) pellets in water to achieve a 14M molar concentration.

How to Determine Molarity

It is necessary to dissolve NaOH solids in water in order to reach the required concentration. You can adjust the mass of NaOH solids needed by adjusting the concentration of the sodium hydroxide solution. Here is the calculation for a 14M solution:

In this case, the molecular weight of NaOH is 40 g/mol. Both the geopolymer combination and the alkaline solution primarily consist of water. A density of 1.268 kg/m³ was recorded for the 14M sodium hydroxide solution.

The Making of an Alkaline Liquid

A common method for making alkaline liquids involves combining sodium hydroxide and sodium silicate solutions and letting them sit at room temperature. This mixing sets in motion the polymerization reaction, which generates a significant amount of heat. Twenty minutes of sitting time will bring the alkaline liquid to room temperature, making it ideal for use as a binding agent.

We chose sodium-based solutions over potassium-based ones due to their lower cost. A technical-grade flake form of sodium hydroxide measuring 3 mm was available. The flake had a specific gravity of 2.130 and was 98% pure. Different mass units, or molarity (M), represent varying concentrations of NaOH solids in a solution.

Digestion of the Blend

Fly ash serves as the sole binder.

Geopolymer Concrete: Preparation, Pouring, and Setting Time

5.3.1Bringing Together

We used an 80-liter rotating pan mixer with stationary blades for the mixing process. For aWe used the pan mixer to dry mix the aggregates and binder materials that comprise the fly ash-based geopolymer concrete for approximately threFigures 10 and 11 depict the sodium hydroxide solution, Figure 12 illustrates any added water, and Figure 13 illustrates any superplasticizer. any). We then added the liquid components of the mixture to the solid components (Fig. 14).

Typically, another four minutes of wet mixing would follow. Fly ash-based fresh geopolymer concrete had a polished appearance and a dark brown color (Fig. 15). The alkaline solution usually made the combinations cohesive.

The concrete compacted in the steel cylinder molds produced sixty final products.

The process involved ten seconds of compaction on a vibratory table, followed by three equal layers of hand strokes per layer (Fig. 16).

TESTS ON CONCRETES DEVELOPED

One key quality of freshly mixed concrete is its workability. One way to describe the concrete is its ease of workability. As part of the work process, you will mix, place, compact, and finish the concrete. Stability, compact ability, and mobility are three difficult rheological properties of fresh concrete. The new concrete was subjected to the following examinations:

Testing for Compaction Factor

A SlumpTest

The purpose of the slump test is to determine whether a particular concrete mix is workable. The droop of fresh concrete refers to the vertical settlement of a typical cone, known as the frustum, under its own weight. It is possible for the concrete cone to break in a slump test under shear, which would raise questions about the stability of the concrete structure. Separation due to lack of stability occurs.

The slump test is not appropriate for extremely stiff blends since it produces extremely tiny slump values that are notoriously difficult to quantify precisely. The Vee Bee time test works well with these types of concrete. For highly workable blends, we measure the slump accurately in inches. Therefore, slump testing is the recommended method in these situations.

Test for Compaction Factor

The purpose of the compaction factor test is to determine whether a given concrete mix is workable. In the lab, we can get a decent idea of this theoretical maximum density by simulating full compaction with mechanical vibration. The compaction factor measures the compatibility of newly mixed concrete.For fly ash-based geopolymer concrete, the slump value ranges from 40 mm to 160 mm and the compaction factor value from 0.85 to 0.96.

Assessment of damage to hard concrete

Assessment of Compressive Strength

A substance or construction's compressive strength refers to its ability to withstand compressive forces acting in an axial direction. When the material exceeds its compressive strength, crushing failure occurs.

This test gives the most insight into the concrete's overall properties and is thus the most important of all the concrete tests.

It is possible to determine the quality of the concrete using just this one test. In this investigation, we used cubes measuring 10 cm by 10 cm by 10 cm instead of the typical cubical molds measuring 15 cm by 15 cm by 15 cm.

We apply oil to the mold to prevent it from sticking.

After adding each of the three equal layers of concrete, the molds vibrate to improve compaction.

All mixtures using different proportions of granite powder as a fine aggregate substitute follow the same procedure.

At 3, 7, 14, and 28 days, the specimens undergo compression testing. We apply a steady pressure of 140 kg/cm2/min to the specimen until it breaks. Just divide the load at failure by the area of the specimen to get the concrete's compressive strength. The following chapter lists the relevant strength values in a table.

Strength Evaluation via Splitting Tensile

Since direct tensile strength tests are not appropriate for this material, we use the splitting method to measure the tensile strength of concrete.

This investigation uses cylinders with a diameter of 10 cm and a height of 15 cm.

We use a tamping rod to compact each of the three equal layers of concrete that we add to the mold.

Putting the molds on a vibrating machine is the next stage.

Every mix that calls for fine aggregate substitution with any amount of granite powder follows this process exactly.

A compression testing machine tests the specimens after 7 days. The splitting tensile strength can be obtained by applying the following formula:

Testing for Flexural Strength

We employed a 100 kN capacity flexural testing machine for this task. Throughout the testing process, we set up the concrete beams to apply the load in the middle third of the span (see Fig. 18). For every specimen, we noted the failure load and the distance from the supports to the spot where the concrete failed. After that, we averaged the flexural strengths of all the evaluated specimens and reported the results.

This is the formula for the specimen's flexural strength (F):

Water absorption tests determine a material's ability to absorb water through capillary action. Geopolymer concrete reinforced with hardened fly ash was evaluated for both its rate of absorption and its durability. We conducted the studies using 28-day-old 100 mm cubes, following ASTM C642-81 guidelines. Each sample was oven-dried for 24 hours at 105°C, and then its dry weight was recorded as $Y1$ W 1. At regular intervals (Y 2 W), the samples were submerged in water, and their weights were recorded until there was a variation of less than 0.2% between subsequent readings. We can use this formula to determine the percentage of absorbed water.

Testing for resistance to acids and sulfates

Strong acids and salts can cause concrete to disintegrate, although this typically takes a very long time. To assess the impacts of acidic and sulfate environments on the concrete in a shorter timescale, we utilized accelerated deterioration processes in a controlled laboratory setting. In this study, we submerged samples of geopolymer concrete containing fly ash in a 25% sodium sulfate (NaSO3) solution with a purity level of 99% by weight and a 5% sulfuric acid (HSO3) solution with a purity level of 98.04%. After considering other approaches, we chose cyclic wetting and drying as the method to evaluate concrete for damage from acid and sulfate attacks.The experiment used beams with dimensions of 10 cm x 10 cm x 50 cm, and cured them at room temperature for 28 days. We maintained the acidic conditions and high sulfate concentrations of the experiment over ten repetitions, spanning twenty weeks. By monitoring the expansion and weight variations of the concrete specimens after 10 cycles, we were able to evaluate their degradation. We placed the prisms in a room-temperature solution five times their volume during the soaking step. In order to dry the specimens evenly, we left them at room temperature with a 50 mm gap between each one.

Ph balance We measured the pH of the concrete to ascertain its alkalinity in accordance with EN 12457. We were able to create a suspension after soaking the polymer concrete in cleaned water for two days. A higher pH indicates that the concrete has a better chance of resisting corrosion, which is one of the most critical elements impacting this property.

Predictions for mixtures with alkaline activators

The molarity of NaOH and the ratio of Na_2SiO_3 to NaOH have a significant impact on the compressive strength of geopolymer concrete. In the first study, the ratio of the Alkaline Activator Solution (AAS) to the Binder Solids (BS) stayed the same at

0.5. However, the molarity of NaOH was changed from 8 M to 16 M, but the ratio of Na_2SiO_3 to NaOH stayed the same. We used this procedure to determine the optimal molarity of NaOH, which we maintained constant while adjusting the ratio of NaSiO2 to NaOH from 0.5 to 2.5.

Laboratory Examination of NaOH Molarities and Densities

The research concluded that a molarity of 14 M NaOH and a ratio of 1.5 Na_2SiO_3 to NaOH are ideal.

With respect to different molarities, Table 6.1 summarizes the compacting factor and slump values.

6.4.1 One cubic meter calculation for the mix design with an AAS/BS ratio of 0.5: Method for Measuring Sodium Hydroxide Solutions

Here is how to determine how much sodium hydroxide you need: To begin, we can use the following formula to find the volume of NaOH:

At AAS to BS ratios ranging from 0.4 to 0.8, acid attack on fly ash-based geopolymer concrete causes weight losses ranging from 1.11.1 percent at the lowest to 2.15 percent at the highest. According to Attiogbe and Rizkalla, standard concrete loses a weight of 10–15% under the same exposure conditions. 1988– 1989. According to Thokchom et al. (2009), this means that all geopolymer concrete can provide excellent resistance to acidic environments.

Fig. 26 evaluates and displays the pH values of powdered, crushed, and pulverized geopolymer concrete samples with various AAS/FA ratios. For fly ash-based concretes, the pH value ranges from 11.84 to 12.98, as seen in the image. The higher concentration of alkaline solutions appears to cause an increase in alkalinity as the AAS/BS ratio rises. But none of the measured values are lower than the 9.5 that Hobbs (1988) cites as the minimum value below which depassivation of steel bars cannot occur in concrete. The alkalinity data indicates that geopolymer concrete provides enhanced resistance to the depassivation of the embedded steel reinforcement.

Optimal Use of Geopolymer Concrete for the Economy

When compared to Portland cement concrete, fly ash-based geopolymer concrete has many positive economic aspects, such as the elimination of cement usage and the significant reduction in energy required for reinforcement manufacture. One ton of Portland cement costs much more than one ton of fly ash.Consequently, after accounting for the cost of alkaline liquids required to produce the material, we anticipate geopolymer concrete to be approximately 10 to 30 percent less expensive than Portland cement concrete. Thus, geopolymer concretes are advantageous and cost-effective for rich and medium mixtures. Additionally, every metric ton of appropriately used fly ash earns a substantial redemption value of approximately one carbon credit. You can make about three cubic meters of high-quality geopolymer concrete from one ton of low-calcium fly ash, which will allow you to profit from the carbon credit trade.

CONCLUSIONS

Thermal power plants used industrial waste, specifically fly ash, to create geopolymer concrete. The alkaline activators utilized were NaOH and Na2SiO3. We conducted extensive experimental investigations to study the mechanical, workability, and durability properties of the geopolymer concrete in depth. The current investigation yielded the following findings:

1. Geopolymer concrete can be made using fly ash, according to the extensive experimental research. Results showed strengths between 23 and 54 MPa for different AAS to BS ratios.

2. Elastic modulus, flexural strength, splitting tensile strength, and compressive strength all declined as the alkali activator percentage increased.

3. Research demonstrates that an increase in the AAS level in the mixture enhances the water absorption qualities, also referred to as the permeability characteristics.

4. When exposed to strong acids and sulfates for an extended period, fly ash-made geopolymer concrete showed remarkable durability. Geopolymer concrete showed the least amount of chemical assault, with a weight loss of no more than 2.15 percent and a gain of just 0.3 percent. These values are significantly lower than those of regular concrete.

5. As the ratio of AAS to BS increased, the alkalinity of geopolymer concrete mixes also increased.

Research shows that geopolymer concrete made with fly ash has amazing chemical resistance, excellent mechanical properties, and permeability qualities. These features support the idea that geopolymer concrete could be a good alternative to traditional Portland cement concrete while making good use of industrial waste.

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