A STUDY OF USES OF VARIOUS INDUSTRY WASTE: GEOPOLYMERS

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Introduction:

Geopolymer is emerging as another development material which could be delivered by the substance activity of inorganic atoms, without utilizing any Portland cement. The geopolymer binder can be produced through chemical reaction between alumino-silicate materials such as fly ash or metakaolin that are rich in SiO_2 and Al_2O_3 and alkaline solutions such as Sodium Hydroxide or Sodium Silicate. Geopolymerisaalumino-silicate material which can be applied for many applications due to the reasonthat geopolymers have several attractive properties of high strength, low permeability, high acid resistance, hazardous materials, and immobilization of toxic materials (Onutai, S). Generally, the geopolymer materials are activated in a high alkali solution (Davidovits, 2008) asalumino silicate geopolymers consist of tetrahedral AlO_4 and SiO_4 units that occur easily in a polycondensed polymer framework in high-alkali conditions (Davidovits, 1991). In geopolymer materials that are prepared at low temperatures with high alkali solutions, generally alumino-silicate materials such as slag metakaolin and fly ash (Ryu, Lee, Koh, & Chung, 2013) are mixed with alkaline solution. Fly ash is a suitable material for making geopolymeric binder because of its pertinent silica and alumina composition and low water demand. Low-calcium fly ash-based geoploymers concrete cured at high temperature are reported to have good mechanical properties in both short and long term tests. The structural behavior of heat-cured fly ash geopolymer concrete has been found to be similar or superior to that of OPC concrete when tested for reinforced columns and beams, bonding and bending properties. Consistently, aluminum utilization is expanding for some applications, for example, anodizing forms for delivering enriching and defensive movies on aluminum and amalgams. The initial step of anodizing procedures is pre-treatment of the metal. The second step is scratching the surface of the aluminum metal in pre-treatment before fixing and shading. This step, which most often uses NaOH in warm solution, gives the metal surface a light grey sati finish. After etching, Al-waste in gibbsite phase ($Al(OH)_3$) is wasted: typically about 360 tons/year from various industries are discarded in landfills. Utilization of non-renewable energy sources in power plants for vitality creation is expanding, leaving fly ashes waste. Around 3 million tons/year of such modern waste are delivered by substantial and little power plants. For fly ash, pozzolanic materials are normally reused in cement and concrete industries. Subsequently, these fly ashes ought to be recovered to create novel materials. On the off chance that individuals can do this, then such materials can end up noticeably reasonable items that give natural, social, and monetary advantages. Particularly, as sustainable assets of both aluminum hydroxide waste and fly ashes remains, these appear to be pertinent for reuse in solid materials. The study would also analysis the effect of degree of heating on compressive strength after specified period of heat curing of fly ash- aluminum based geopolymer mortar.

OBJECTIVES:

The present study has the following objectives:

a. To identify the application of available industrial waste, i.e., fly-ash in a useful manner by blending it into aluminum/aluminum—magnesium matrix to produce composites by a liquid metallurgy route.
b. To demonstrate the enhancement in the strength of the geoploymers on adding aluminum to the mixture,
c. To identify the change in the properties of the geoploymers on experimenting with different percentages of aluminum,
d. To get the maximum use of the aluminum and fly ash material in order to make sustainable concrete materials,
e. To study the mechanical properties like compressive strength, tensile strength, bending strength, hardness of the fly-ash aluminum based geoploymers.

LITERATURE REVIEW

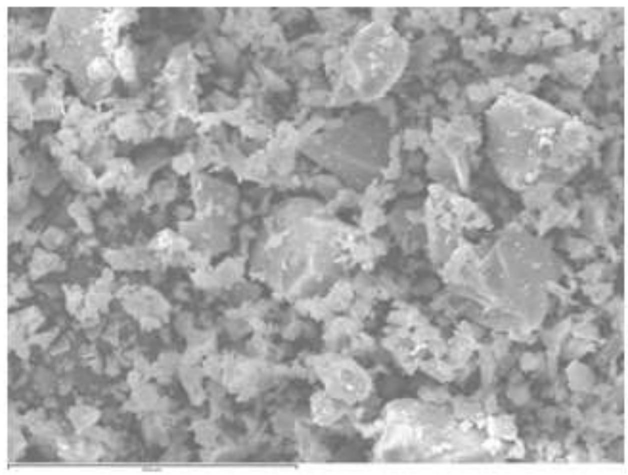
Patankar et al., (2012) presented the effect of concentration of temperature,sodium hydroxide, and duration of oven heating on compressive strength of fly ash-based geopolymer mortar. Sodium silicate solution containing Na_2O of 16.45%, SiO_2 of 34.35%, and H_2O of 49.20% and sodium hydroxide solution of 2.91, 5.60, 8.10, 11.01, 13.11, and 15.08. Moles concentrations were used as alkaline activators. Geopolymer mortar mixes had been prepared by considering solution-to-fly ash ratio of 0.35, 0.40, and 0.45. The temperature of oven curing was maintained at 40, 60, 90, and 120°C each for a heating period of 24 hours and tested forcompressive strength at the age of 3 days as test period after specified degree of heating. Test comes about demonstrate that the workability and compressive quality both increment with increment in convergence of sodium hydroxide answer for all answer for fly slag proportions. Degree of heating also plays vital role in accelerating the strength; however there is no large change in compressive strength beyond test period of three days after specified period of oven heating.

Kulkarni et al., (2013) directed the review to beat the issues confronted in traditional materials, and additionally to lessen the cost of composites. Aluminum materials observed to be the best option with its attributes like high strength to weight ratio and low density. In this project we are casting aluminum based (Al 6061) composites with silicon carbide and fly ash as reinforcements, fly ash is one of the inexpensive and low density material enormously available as a byproduct during coal combustion. And then the casted components are machined to specimen dimensions and different material testing had been conducted to obtain the material properties and characteristics. The author has varied mass fraction of and fly ash (9%, 12%, & 15%) and kept SiC as constant of 9%. The author had got well progressions in mechanical properties like malleable, pressure and hardness with the expansion in weight % of fortification.

Tashima et al., (2013) studied the influence of curing time on the microstructure and mechanical strength enhancement of alkali activated binders based on vitreous calcium aluminosilicate (VCAS) (Table 2.3 shows the Chemical Composition of VCAS (weight %)). For different curing times (4–168 h), mechanical strength of alkali activated mortars has been assessedat 65°C using 10 molalNaOH solution as alkaline activator.

Table : Chemical Composition of VCAS (wt %)(Tashima et al., 2013)

SiO_2	Al_2O_3	CaO	MgO	Na_2O	K_2O	Fe_2O_3	Others
57·9	12·92	23·51	2·88	0·74	0·13	0·47	1·45



Singh et al., (2015)gave an outline of advances in geopolymers formed by the alkaline activation of alumino-silicates is presented alongwith opportunities for their use in building construction. The properties of mortars/concrete made from geopolymeric binders has been discussed with respect to fresh and hardened states, interfacial transition zone between aggregate and geopolymer, bond with steel reinforcing bars and resistance to elevated temperature. The durability of geopolymer pastes and concrete has been highlighted in terms of their deterioration in various aggressive environments. R&D works carried out on heat and ambient cured geopolymers at CSIR-CBRI are briefly outlined alongwith the product developments. Examine discoveries have uncovered that geopolymer concrete displayed relative properties to that of OPC solid which can possibly be utilized as a part of structural designing applications.

Fan (2014) investigated the thermo-mechanical properties of a concrete arranged utilizing a class F fly fiery remains and three distinctive soluble base activators (NaOH activator, NaOH and Na_2SiO_3 blend activator, and KOH and Na_2SiO_3 blend activator) is introduced. The mechanical properties, including the compressive quality, shrinkage, weight reduction, and compound arrangement, are examined using a few key instruments, for example, X-beam Diffraction (XRD), Scanning Electron Microscopy (SEM), and Energy Dispersive X-beam Spectroscopy (EDXS) estimations. The impacts of the water/powder proportion, curing strategies, cooling techniques, and fixing degree on the compressive quality and warm properties of the geopolymer items are examined and broke down in points of interest. The tried outcomes demonstrate that the geopolymer bond cured at suitable conditions can achieve a compressive quality of more than 100MPa and it additionally has an astounding warmth resistance with a surprising quality after the 500ºC warming.

Likewise, it is found that the examined geopolymer bond has a significantly higher spallation resistance when all of a sudden chilled off by water after the high temperature warming than the normal Portland concrete solid which has a high spallation propensity. These discoveries demonstrate that the geopolymer bond might be an astounding development material for the fire assurance and fire-inclined structures.

Muruganandhan and Eswaramoorthi(2014) have used fly ash as the reinforcement to produce the composite by stir casting. Fly ash has been chosen because of it is least expensive and low density reinforcement available in large quantities as solid waste byproduct during combustion of coal in thermal power plants. Due to low weight it can be applied in automobile and thus improving its life. The review has revealed that increase in mechanical properties up to 20% of fly ash in the matrix material. But the corrosion resistance decreases with the fly ash addition. Fly ash plays a significant role in strengthening the mechanical property. The past outcome indicates 10 to 20% expansion in mechanical properties. The rigidity, pressure quality and hardness get enhanced by including fly ash remains. The utilization of aluminum can be limited by upholding the fly ash waste. SEM investigation is done to know the circulation of fly slag with the composite.

Onutai et al., (2015) has described the reuse of aluminum hydroxide waste (Al-waste) for geopolymers. For cement materials, both Al-waste and fly ash (FA) were mixed at different Al-waste contents of 10–60 weight%. The mass ratio of sodium silicate (Na_2SiO_3) to sodium hydroxide (NaOH) solution was fixed at 2.5. Here, the NaOH concentrations of 5, 10, and 15 M were used as alkaline activators for geopolymerization. Viscoelasticity measurements were used to evaluateslurry properties for the geopolymers. It demonstrated that slurry containing higher alumina has a higher elastic modulus and that the setting time is greater than that for pure FA. Then, cured at room temperature for a week and also in an oven at 60°C and 80°C for 24 h, the geopolymerization was increased with increasing concentration of NaOH. Microstructure, mechanical properties, bonding, and phases of the resultant geopolymers were ascertained after curing. The contents of the Al-waste in the geopolymer influenced the geopolymerstrength when NaOH concentration was changed at different curing temperatures

EXPERIMENTAL PROCEDURE:

Geopolymers

Inquire about reviews in the past had demonstrated that fly ash based geopolymer has developed as a promising new cement alternative in the field of construction materials. Hardjito and Rangan shown in their broad reviews that geopolymer based cement demonstrated great mechanical properties when as compared to conventional cement concrete. Geopolymer can be produced with the basic raw materials containing silica and alumina rich mineral composition. Several studies have reported the use of the beneficial utilization of these materials in concrete. Most of the studies investigated the use of alkali activators containingpotassium hydroxide and potassium silicate or sodium hydroxide and sodium silicate. Cheng and Chiuhasreported the production of geopolymer concrete usingmetakaolin and slag with potassium hydroxide and sodium silicate as analkaline medium. Palomo et al., created geopolymers utilizing fly ash waste with sodium hydroxide and sodium silicate and in addition with potassium hydroxide with potassium silicate mixes. The outcomes from the reviews displayed an astounding development of geopolymer with quick setting properties. It can be noted that the presence of calcium content in fly ash played a significant role in compressive strength development. The presence of calcium ions provides a faster reactivity and thus yields good hardening of geopolymer in shorter curing time.

Following materials are generally used to produce GPCCs:

- Fly ash,
- GGBS,
- Fine aggregates and
- Coarse aggregates

i. Catalytic liquid system (CLS): It is an alkaline activator arrangement (AAS) for GPCC. It is a blend of arrangements of soluble base silicates and hydroxides, other than refined water. The part of AAS is to activate the geopolymeric source materials (containing Si and Al, for example, fly ash waste and GGBS.

Mechanical Properties

a. Compressive Strength:

With appropriate detailing of blend fixings, 24 hour compressive qualities of 25 to 35 MPa can be effortlessly accomplished with no requirement for any uncommon curing. Such blends can be considered as self -curing. However, GPCC mixes with 28 day strengths up to about 50-80 MPa
has been developed at SERC.

b. Modulus of Elasticity:

The Young's modulus or modulus of elasticity (ME), Ec of GPCC is taken as tangent modulus measured at the stress level equal to 40 percent of the average compressive strength of concrete cylinders. The MEs of GPCCs are insignificantly lower than that of customary cement concretes (CCs), at similar strength levels.

c. Stress Strain Curves:

The stress-strain relationship depends upon the ingredients of GPCCs and the curing time.

d. Rate of Development of Strength This is generally faster in GPCCs, as compared to CCs.

e. Long Term Durability Properties of Geopolymer Concrete

Durability aspects of geopolymer products have good sustainability to weathering effects; however, they are susceptible towards high temperature beyond 400°C. Several experimental studies have provedthat geopolymer concrete specimens immersed inchloric acid and sulfuric acid have been found to be resistant to acid attack. There are currently four different geopolymer categories including:

- Slag based geopolymer
- Rock based geopolymer
- Fly ash based geopolymer
- Ferro-sialate based geopolymer

Slag Based Geopolymer

The first geopolymer developed was a slag based geopolymer in the 1980s. The reason for using this type of cement is due to its the rapid strength gain as it can reach strengths of up to 20 MPa in just after 4 hours. Slag is a by-product in the process of melting iron ore and a partially transparent material and. It generally comprises of a blend of metal oxides and silicon dioxide.It is additionally utilized in the cement and concrete industry. The substitution of OPC with slag is one of the many advantages that it gives to OPC solid, diminishing life cycle costs and enhancing the workability of the new concrete, Easier finishability, higher compressive and flexural quality and furthermore the enhanced imperviousness to corrosive materials. The reactions of slagin cement blends and in alkali activating systems are dominated by the minute particles. The particles under 2 µm react completely within 24 hours, while that above 20 µm usually react slowly, while particles. Thus, careful control of the particle size distribution must be ensured to control the strength of the binderwhen slag is used in geopolymerisation.

Rock based Geopolymer

To compose geopolymer of this type, a fraction of the MK-750 ("MK" is an abbreviation for metakaolin and the "750 " represents the temperature at which it has been produced) in the slag based geopolymer is replaced by natural rock forming materials such as feldspar and quarts. This blend yields a geopolymer with better properties and less CO_2 outflows than that of the ordinary slag based geopolymer. The components of rock based geopolymer cement is blast-furnace slag, natural rock forming materials (non-calcinedorcalcined), metakaolin MK-750, and a user friendly alkali silicate.

Fly Ash Based Geopolymer

Fly ash is the waste material produced in the blast furnace. Components of fly ash are amorphous composition (62%), quartz (23%), mullite (16%), maghemite (1.9%) and hematite (.7%).Fly ash is commonly used as a substitute for Ordinary Portland cement in concrete and the addition of it provides;

- Fly powder comprises of circular particles which enhance the workability of the fresh OPC concrete. This empowers one to reduce the measure of water in the blend which diminishes the measure of bleeding in OPC cement,
- Improves mechanical properties, for example, guarantees a higher reactiveness, compressive strength, because of the water lessening and better "packing" of particles,
- Making OPC concrete economical
- Reduces drying shrinkage and the CO_2discharges ,

- Smoother surface.

The Figure shows the graded fly ash.

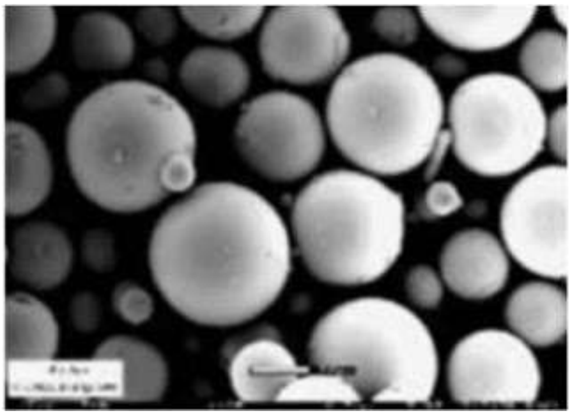


Figure Graded fly ash

Most of thefly ash material available globally is low calcium by product obtained from the burning of anthracite and bituminous coal. Fly ash can be categorized in to two, type C fly ash and type F fly ash. The type F fly ash can be again classified into two Fly ash/slag based geopolymer and alkali-activated fly ash geopolymer.

Alkali-activated fly ash geopolymer

This kind of geopolymer usually requires heat curing at 55 ºC to 85 ºC and is known as the alkali activation method. The mixture consists of fly ash and sodium hydroxide solution. The fly ash particles are embedded into an aluminosilicate gel with a Si: Al ratio of 1 to 2. A high concentration of sodium hydroxide solution is required to ensure an adequate geopolymerisation process.

Fly ash/slag based geopolymer

This sort of geopolymer is more easy to use and it hardens at room temperature. The mixture consists of, blast furnace slag, a user-friendly silicate and fly ash. The fly ash particles are embedded into a geopolymer matrix with and Si: Al ratio of 2.

Ferro Sialate Based Geopolymer

This type of geopolymer contains geological elements with high iron oxide content, giving the geopolymer a red colour. It has the similar properties as rock based geopolymers but Some of the aluminum atoms in the matrix are substituted with iron ions to yield a poly (Ferro-sialate) type geopolymer with the following formation: (Ca,K)- (-Fe-O)-(-Si-O-Al-O-).

CONCLUSIONS:

The study was conducted to examine the fly-ash geopolymers based concrete and its applications. The study investigated various aspects of the composite mixture like compressive strength, tensile strength, hardness and so forth. Fly-ash Aluminum based geopolymer concrete is well known for its acid resistance, promising mechanical properties and fire resistance and therefore is a potential alternative construction material with comparable properties to OPC concrete. The constituents of Fly-ash Aluminum based geopolymer concrete are capable of being mixed with a relatively low alkali activating solution It can be cured in a reasonable time under ambient conditions. Geopolymers emit approximately 80% less CO_2 than OPC during production, making it a more environmental friendly building material. geopolymer concrete has a brittle failure, like OPC concrete. Fibres can be added to improve the ductility of concrete as an alternate solution. The properties of geopolymerincludelowshrinkage,sulphateresistance,high early strength, freeze-thaw resistance, and corrosion resistance.

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