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A REVIEW OF GEO POLYMER CONCRETE BY USING VARIOUS INDUSTRIAL WASTE MATERIALS

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ABSTRACT

The infrastructure market is expanding quickly in emerging nations. The price and accessibility of building supplies are essential to sustaining this development trajectory. Industrial waste is a major source of worry for the environment, human health, and land filling in the modern day. Recycling these wastes and using them as building materials seems to be a practical way to reduce pollution and also a cost-effective way to build. When it comes to choosing materials for any kind of building, there are plenty of options. Architects and engineers are incentivized to choose more sustainable materials due to the increased interest in sustainable building. Geo polymer concrete is more environmentally friendly than nominal concrete since it replaces ingredients. Fly ash and an alkaline solution are used as binding agents. Compressive power of After reviewing geo polymer concrete containing various waste components, suggestions are made in light of the study's findings. The method for creating new building materials out of industrial waste that has been studied is helpful in offering a possible sustainable supply. The primary goal of this research is to replace natural resources with a variety of industrial waste materials, such as waste glass powder, fly ash, copper slag, steel slag, granite slurry, bottom ash, M-Sand, Micro Silica, Nano Silica, Foundry Sand, etc., in order to increase the strength and lower the cost of Geo polymer concrete. This essay discusses the literature on geo polymer concrete, which substitutes natural resources for a variety of industrial wastes, including waste glass powder, fly ash, bottom ash, copper slag, etc. This study reviews the state of the geo polymer concrete research field.

Keywords: Geo polymer Concrete, Natural Resources Replacement, Fly Ash, GGBS, Waste Glass Powder, Granite slurry, bottom ash, Copper slag, M-Sand, Micro Silica, Nano Silica, Foundry Sand, Steel Slag, E- Waste.

1. INTRODUCTION

In recent years, the Portland cement concrete business has expanded to a global scale. The improvement of infrastructure has increased demand for concrete as a building material. However, issues like global warming and carbon dioxide emissions are brought about by the manufacture of Portland cement concrete. Over 2,500 million tones of trash are produced year by human activity on Earth, comprising industrial and agricultural waste from both rural and urban populations. This leads to major issues with land filling, the ecology, and human health. The most widely utilized artificial material in the world today is concrete.

About 400 million tones of concrete and a comparable quantity of mortar are used annually by the Indian building sector alone. As a result, there is a huge demand for both raw materials and concrete. Cement and fine and coarse aggregate prices have increased as a result. There is sometimes a scarcity of these resources as well. Waste materials should be recycled to provide partial or alternative resources for cement and aggregate in order to prevent issues like rising costs and shortages of these commodities. This gives us access to affordable, lightweight, and environmentally friendly building materials. Utilizing waste products also lessens the issue of land-filling and other environmental and health risks.

Joseph Davidovits created geo polymers, inorganic polymeric binding materials, in 1970.One kind of amorphous aluminium silicate cementation material that exhibits the optimal characteristics of minerals that form rocks is called geo polymer. Davidovits suggested that in a source material having geological origins, an alkaline liquid may be used to react with silicon and aluminum.

Flyash geo polymers have been processed into concretes, mortars, and pastes. The two primary components of geo polymer are the alkaline liquids and the source materials. The raw elements for geo polymers come from naturally occurring minerals that are high in silicon and aluminium. The soluble alkali metals, mostly potassium or sodium, are the source of the alkaline liquid. Combining sodium silicate with hydroxide is the most frequent alkaline liquid used in geo polymerization. Concentrated alkaline solution and material containing alumino silicate (source material) react to produce geo polymer.

2. PREVIOUS RESEARCH REVIEW BASED ON GEO POLYMER CONCRETE BY USING VARIOUS INDUSTRIAL WASTE MATERIALS

Ganapati Naidu et al. (2018) has looked at the strength characteristics of geo polymer concrete by substituting slag in five different percentages for low calcium fly ash.Sodium hydroxide (41 kg/m3) and sodium silicate (103 kg/m3) solutions were used as alkalis in each of the five distinct mixes (M1, M2, and M5). A maximum compressive strength of 57 MPa was attained for 28 days with a maximum (28.57%) replacement of fly ash with slag (Mix no 5). The same mixture (Mix No. 5) exhibits 43.56 MPa after a 2-hour exposure to 500°C. Geo polymer concrete with greater GGBS concentrations has a higher compressive strength. G.G.B.S. mixing was tested up to 28.57%; anything over that was noted right away. If GGBS replaces at least 9% of the fly ash in geo polymer concrete, then exposure to a higher temperature is not required to achieve maximal strength. In only 14 days, 90% of the compressive strength was reached.

Prof. M. A. Bhosale et al. (2018) has reported on the investigation of the processing of geo polymer utilising fly ash as a fly-hand alkaline activator with geo polymerization process and explained the mechanism of activation of a fly ash (no other solid material was employed) with extremely alkaline solutions. Studies have been conducted on the variables, such as sodium hydroxide (NaOH) molarities, that affect early age compressive strength. In this research, the ratios of Na2Si03 and NaOH at values of 0.39 and 2.51 are compared. The samples of geo polymer paste were cured for one day at 60°C and then kept at room temperature until the testing days. The results demonstrated that the compressive strength of the geo polymer paste with NaOH concentration increased with molarities and that this relationship was revealed with the preparation of test samples of fly ash with geo polymers of varying composition in the ratio of 0.39 & 2.51.The samples are made in a range of molarities, including 8, 10, 12, and 14. In Case 1: Na2SiO3/NaOH ratio is 2.51. The fly ash-based geo polymer concrete has a better compressive strength due to a higher concentration of solutions per molar. Case 2: With a ratio of 0.39 for Na2SiO3/NaOH It has been noted that compressive strength rises with increasing morality when the quantities of sodium hydroxide and sodium silicate are reversed by mass. In comparison to specimens kept at room temperature, compressive strength is higher in instances 1 and 2 for oven drying. A test of compressive strength is conducted.

Mr. Bennet Jose Mathew et al. (2018) has investigated the viability of producing coarser bottom ash for use in geo polymer concrete, the impact of adding bottom ash in different proportions in lieu of fly ash on the material's strength, and the influence of curing techniques on the strength of fly ash-GGBS based geo polymer concrete. Studies on the economic effects and sustainability of geo polymer and OPC-based concrete were carried out. Due to its huge particle size, bottom ash-GGBS based geo polymer concrete yielded relatively poor strength. If the raw material transportation infrastructure is well-established, geo polymer concrete may be produced at a cost that is equivalent to that of OPC-based concrete. Compared to OPC-based concrete, fly ash-GGBS geo polymer concrete has 40% less embodied energy. The majority of the embodied energy in geo polymer concrete is contributed by sodium hydroxide (39%) and sodium silicate (49%) combined, while approximately 94% of the embodied energy in OPC cement is contributed by cement.

Ravindra Singh Shekhawat et al.(2019) The aim of the thesis was to examine the potential of using LD slag in geo polymer concrete and to investigate the use of steel slag as a raw material for the production of M20 grade geo polymer concrete. Steel slag has a lower reactivity in the geo polymer system and was combined with fly ash and granulated blast furnace slag. An isothermal conduction calorimeter has been used to study the behavior of geo polymerization. The produced geo polymer concrete has compressive strength that is comparable to that of M20 grade concrete. Although the anticipated strength of 25 MPa is possible, the required strength is not being obtained. After 28 days, a minimum of 13.45 N/mm2 and a high of 24.15 N/mm2 were reached. One of the potential causes of this decline in strength might be the composition's proportion of binders.

B. Rajini et al. (2019) Studying GGBS and fly ash as distinct replacement levels (FA0-GGBS100, FA25-GGBS75, FA50-GGBS50; FA75-GGBS25, FA100, GGBS0) was the aim of his thesis. For the FA0-GGBS100, the maximum compressive strength and split tensile strength of geo polymer concrete are, respectively, 54.29 N/mm2 and 2.46 N/mm2, regardless of the curing time. After seven days of curing, the rate at which geo polymer concrete gains compressive strength and split tensile strength decreases with age.

A. Rajerajeswari et al. (2019) has investigated the potential of silica fume-based geo polymer concrete to determine its compressive strength by taking into account variables like the influence of the Na2Sio3/NaOH ratio, the AL/SF ratio, and the age of the concrete. Based on the experimental examination, it was determined that four various ages of silica fume based geo polymer concrete with AL/SF=0.25 and Na2SiO3/NaOH=0.5 gave greater gains in compressive strength out of three different ratios of Na2Sio3. For all ratios of Na2SiO3/NaOH, there is a gain in strength of 73%

for 3 to 7 days, 38% for 7 to 28 days, and 15% for 28 to 56 days when the AL/SF ratio=0.25 is taken into account. Comparing this to conventional concrete under normal curing conditions, the Na2SiO3/NaOH=0.5 results in an increase in strength of 84% for 3 to 7, 38% for 7 to 28, 15% for 28 to 56 days for all ratios of AL/SF ratios, and 60% replacements of silica fume yielded better compressive strength.

T.V. Srinivas Murthy et al. (2020) has studied to produce the geo-polymer concrete, the Portland cement is fully replaced with GGBS (Ground granulated blast furnace slag) and alkaline liquids are used for the binding of materials. The curing is carried in oven, curing at 65ºC. For this study M50 concretemixwasused forexperimentalwork andresults of testshowthattheuse of GGB Sbased geo polymer concrete increases in compressive strength, Split tensile strength and Flexural strength respectively by 13.82%, 18.23%, 30.19% as compared with conventional concrete

L. Krishnan et al. (2020) The primary goal of his thesis was to create a cementations material that emits no carbon dioxide. He also investigated the main drawbacks of fly ash-based geo polymer concrete, including its slow setting at room temperature and the need for heat curing, which can be overcome by adding ground granulated blast furnace slag (GGBS) powder. The results of the tests indicate that the geo polymer concrete cubes gain strength in less than a day without the need for water curing at room temperature, and t The mix Id F60G40 was found to have a maximum compressive strength of 80.50 N/mm2. Additionally, the mix F60G40's splitting tensile strength and flexural strength were completed.

C. Sreenivasulu et al. (2020) has looked at analyzing the mechanical characteristics of geo polymer concrete (GPC) by substituting granite slurry (GS) for sand. Different replacement thresholds (0%, 20%, 40%, and 60%) were applied to GS. As geo polymer binders, a 50:50 mixture of fly ash and ground granulated blast furnace slag (GGBS) was used. It is determined that sand can be replaced with GS at the ideal replacement level of 40%.

Jerusha Susan Joy et al. (2020) has conducted research to see if recycled foundry sand may replace some of the fine aggregate in geo polymer concrete. In this research, foundry sand is substituted for fine aggregate at weights of 0%, 5%, 10%, 15%, 20%, and 25%. Through oven curing at 800C, the geo polymer concrete with a silica ash and GGBS foundation became stronger over a shorter period of time. The mix's maximum strength is 21.33 N/mm2 when fine aggregate is replaced at a rate of 15%. It was discovered that 15% replacement was the ideal quantity.

Janardhanan Thaarrini et al. (2020) has investigated the viability of producing geo polymer concrete at lower densities and low concentrations of alkaline solutions, while integrating waste materials such as foundry sand without adjusting for strength characteristics. Based on initial research, a 50:50 substitution of natural sand with foundry sand is assumed. The following range of densities was selected: 1800, 2000, 2200, and 2400 kg/m3. A percentage ratio of 0, 25, 50, 75, and 100 was chosen for the BA-GGBFS.BA-GGBFS-FSAn intriguing result of this study is that geo polymer blocks have adequate strength even at lower molarities of 4M NAOH solution under ambient curing conditions. The compressive strength rises with increasing slag amount up to a 50% replacement, after which it falls. In comparison to regular concrete, geo polymer concrete absorbs less water and exhibits superior resistance to sulphate and chloride attacks. River sand may be substituted with foundry sand up to a 50% ratio without compromising the strength of geo polymer concrete.

Shalika Sharma et al. (2015) Research was done on how the curing temperature affected the abrasion resistance of geo polymer concrete. While geo polymer concrete at high temperatures may be cured in 72 hours, samples treated at 250C need 120 hours to cure, and as temperature rises, so does abrasion resistance.

O. M. Omar et al. (2020) has looked at the conventional testing methods for hardening concrete for specific cement and geo polymer concrete mixtures. Local steel slag was discovered to improve the slump of new cement and geo polymer concretes when used as a coarse aggregate. It was observed that the compressive strength of the geo polymer concrete mix created using crushed stone as coarse aggregates was less than 6% when local steel slag replacements, 100 percent of which were used as coarse aggregate, were used. Higher ratios of sodium silicate to sodium hydroxide by mass also lead to higher compressive strengths of fly ash-based geo polymer concrete. Higher concentrations of sodium hydroxide solution (measured in molar terms) also result in higher compressive strengths of fly ash-based geo polymer concrete.

Yagnesh Patel et al. (2020) His thesis's goal was to conduct an experiment on low-calcium fly ash-based geo polymer concrete with three distinct activator liquid molar concentrations and varying amounts of nanosilica addition. The compressive strength, weight loss percentage, and compressive strength loss percentage were measured throughout the studies, and the results showed the impact of adding various amounts of nanosilica to the low calcium fly ash-based geo polymer concrete. According to experimental data, the compressive strength of calcium fly ash-based geo polymer concrete rose as the quantity of nano silica in the mix increased.GPC specimens with 12M and 1.5% NS had a compressive strength that was 1.20 times more than those with 8M and 1.5% NS, but only slightly higher than that with 16M and 1.5% NS after 28 days. In the durability test, weight loss from the chloride effect is lessened as molarity increases, and there is also a little reduction when the proportion of nano silica increases. The parameters of durability and compressive strength of geo polymer concrete are impacted by nano silica.

Shalika Sharma et al. (2020) His thesis sought to determine how variations in curing temperature and time affected the compressive strength of geo polymer concrete. It was discovered that the sample of geo polymer concrete with a ratio of 0.4 for fly ash to alkaline liquid and a ratio of 2 for NaOH to Na2SiO3 that was cured at 250C needed 120 hours to cure, but the compressive strength was still extremely low.The samples that were cured at 60°C and 800°C needed less time to cure—72 hours—and had higher compressive strength.

Dr. I.R. Mithanthaya et al. (2020) has investigated the effect of glass powder (GP) and ground granulated blast furnace slag (GGBS) on the compressive strength of Fly ash based geo polymer concrete. The mass ratio of fine aggregate (FA) to coarse aggregate (CA) was maintained constant.

The ranges of investigation parameters include GP/FA from 0% to 20%, and GGBS/ FAfrom 0% to 20% with constant amount of GP. Replacement of FA by GP up to 15% is useful in increased compressive strength up to 20Mpa. 10% replacement of FA by GP and further replacement ofFAbyGGBS upto15%increasesthestren gthofconcreteupto32Mpa.Geo polymer concretewith compressive strength of 30Mpa and water absorption less than 7% can be obtained using only industrial waste materials without using Sodium Silicate or heating to higher temperature. Geo- polymer concrete is about 14 % cheaper compared to concrete using PC.

Nitendra Palankar a et al. (2021) has researched to focus on development of alternative binder materials to Ordinary Portland Cement (OPC) due to huge emissions of greenhouse gases associated with production of OPC and conducted to evaluate the performance of weathered steel slag coarse aggregates in GGBFS-FA based geo polymer concrete. GGBFS-FA geo polymer concrete with steel slag coarse aggregates are prepared by replacing natural granite aggregates at different replacement levels i.e. 0%, 25%, 50%, 75% and 100% (by volume) and various fresh and mechanical propertiesare studied and results of test indicated that incorporation of steel slag in GGBFS-FA geo polymer concrete resulted in slight reduction in mechanical strength.

The water absorption and volume of permeable voids displayed higher values with inclusion of steel slag. The fatigue resistance of GGBFS-FA geo polymer concrete mixes decreased with the replacement of granite aggregates with higher contents of steel slag aggregates. GGBFS-FA geo polymer mixes with steel slag coarse aggregates recorded slightly lower compressive strength along with lower tensile strength and modulus of elasticity as compared to GGBFSFA geo polymer with granite aggregates; due to the presence of a thin layer of calcite on the aggregate surface thus leading to a weak aggregate-paste interface.

Dr. M.R. Sinhaa et al. (2021) has investigated the effect of glass powder (GP) and ground granulated blast furnace slag (GGBS) on the compressive strength of Fly ash based geo polymer concrete. The mass ratio of fine aggregate (FA) to coarse aggregate (CA) was maintained constant.

The ranges of investigation parameters include GP/FA from 0% to 20%, and GGBS/ FAfrom 0% to 20% with constant amount of GP. Replacement of FA by GP up to 15% is useful in increased compressive strength up to 20Mpa. 10% replacement of FA by GP and further replacement ofFAby GGBS upto15% increases thestren gthofconcreteupto32Mpa.Geo polymer concretewith compressive strength of 30Mpa and water absorption less than 7% can be obtained using only industrial waste materials without using Sodium Silicate or heating to higher temperature. Geo- polymer concrete is about 14 % cheaper compared to concrete using PC.

P. Pavani et al. (2022) He studied the engineering properties of GPC (FA50-GGBS50), i.e., FA50-GGBS50-GS0, FA50-GGBS50-GS20, and FA50-GGBS50-GS40, and examined the strength properties of class F flyash (FA) based geo polymer concrete (GPC) using granite slurry powder (GS) as sand replacement at different levels (0%, 20%, and 40%).

It is determined that the compressive strength and breaking tensile strength values of GPC mixes were enhanced by the higher replacement amount of granite slurry powder (GS). For seven days, 28 days, and ninety days, the maximum compressive strength and split-tensile strength of geo polymer concrete are 42.14 N/mm2, 56.32 N/mm2, 68.36 N/mm2, and 2.75 N/mm2, 3.61 N/mm2, and 4.6 N/mm2, respectively.FA50-GGBS50-GS40 is the best substitute. Based on previous research review, history related to the use of industrial waste materials for making of Geo polymer concrete is shown in figure 1.

3. HISTORICAL DEVELOPMENT RELATED TO USE OF INDUSTRIAL WASTE

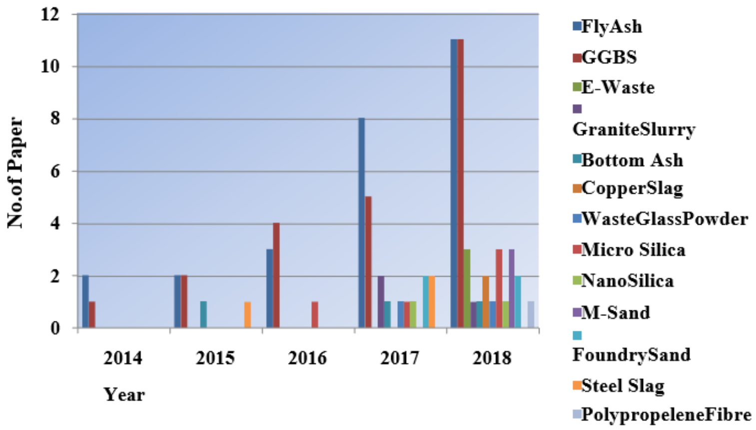

Figure1. History of use of industrial waste material

4. CONCLUSION

The literature research focused on the use of industrial waste to make geopolymer concrete came to the conclusion that the total cost of producing the material may be decreased by partially substituting different industrial waste materials for fine aggregate, coarse aggregate, cement, and sand in the design mix. It can reduce the disposal problems of Industrial waste materials and also consume the cement used for making of Geo polymer concrete.

1) Different tests have been conducted as per the standards on the Geo polymer concrete. The common parameter calculated by various researchers is compressive strength.
2) It is seen that waste materials like fly ash, GGBS, Micro silica were used extensively and sufficient research have been done on them.
3) When cement is replaced by various industrial waste compressive strength, flexural strength and split tensile strength of Geo polymer concrete for various mixes is depends upon the type of Industrial waste materials used for making of Geo polymer concrete.
4) For those resource individuals interested in developing sustainable building materials from industrial or agricultural waste, the research is helpful.

The aim of the thesis was to examine the potential of using LD slag in geo polymer concrete and to investigate the use of steel slag as a raw material for the production of M20 grade geo polymer concrete. Steel slag has a lower reactivity in the geo polymer system and was combined with fly ash and granulated blast furnace slag. An isothermal conduction calorimeter has been used to study the behavior of geo polymerization. The produced geo polymer concrete has compressive strength that is comparable to that of M20 grade concrete.

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