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Review Paper on Geopolymer Foam Concrete Using Fly Ash

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ABTRACT

Fly ash concrete has economical and environmental advantages. It also makes concrete sustainable. In India presently less than 50% of fly ash produced is consumed. Infrastructural Development is at its peak all over the world and is a symbol of growth for any country. The most popular construction material, involves use of cement which is responsible for 7% of total world's carbon dioxide emissions. Carbon dioxide is the main threat in causing global warming of the environment. The attempts have been made to reduce CO2emissions in environment by all possible ways, but cement has not found a suitable replacement for it till date. Fly ash Concrete is an effort in reducing cement content of construction. The paper aims at discussing the use of fly ash concrete in construction as a solution to address two environmental problems - one, disposal of huge amounts of fly ash, by production of thermal power plants, causing environmental degradation through large areas of landfills and two, high percentage of carbon dioxide emissions in atmosphere from cement industry. Key Words : Cement, fly ash, Concrete, fly ash concrete, Environment.

Keywords: Sugarcane bagasse ash, Quarry dust, strength properties of conventional concrete.

Introduction

Geopolymer Concrete

GPC is an inorganic polymer formed from silica and alumina-rich agricultural and industrial waste that is thrown in the open. This same GPC is a hardened binder made up of alumina and silica from thermally induced natural materials like kaolinite and bentonite, and also industrial by-products like fly ash (FA), rice husk ash (RHA), and wheat straw ash (WSA), as well as activating solutions which polymerize these components into molecular chains and networks. GPC is commonly referred to as alkali-activated materials (AAMs), yet the two systems have quite distinct chemistry. Geo polymerization forms a 3-D stable polymer structure, whereas AAM activation is a short-term process that produces unstable monomers. When compared to GPC, the AAMs have a high strength but a low durability. Depending on how the activator sourceis added, GPC can be one-part or two-part. In one-part GPC, sometimes known as "Just Add Water," the activators are used in solid form rather than liquid form thus, a dry mixture is requiredbefore adding water. The dry combination contains solid aluminosilicates and solid alkaline activators. In two-part GPC, commonly known as conventional GPC, the activators are introduced in liquid form with water in a solid alumino silicate precursor

Fly ash

Fly ashes (FA) are the most common coal combustion byproducts in thermoelectric power plants. They are made from diverse inorganic and organic elements in feed coals at temperatures rangingfrom 1200-1700°C. FA is one of the most difficult matrixes for scientific inquiry among naturalrocks and technogenic products due to the variety in coal compositions as a function of their origin. Even if the original coal is the same, the glass, mullite, and quartz content is affected by the combustion temperature, which varies from 1200 to 1700°C

Objectives of the Work

The major objective of the paper is to explain of utilization of of coal fly ash geopolymer and it aggregates such as alkaline solution binding ratio, condition of curing geopolymers concrete at different ages.

Literature Survey & Background

In this [1] authors discussed the Geopolymer concrete is a relatively new discovery in concrete technology that is continually evolving. The impact of various curing techniques on the compressive strength of fly ash-based geopolymer concrete is highlighted in this study. By altering the fineness and quantity of fly ash, three different curing systems were examined for research. Hot air oven curing, solar oven curing, and atmospheric curing are the three types of curing systems. The outcomes suggest that solar oven curing of geopolymer concrete improves compressive strength when compared to air temperature curing.

The impact of several curing techniques on the compressive strength of fly ash-based geopolymer concrete was studied in this article. The following findings were obtained depend on the research work: In the development of geopolymer concrete, fly ash fineness and curing temperature are critical. Higher source material fineness resulted in higher compressive strength under oven and solar heating, as well as when heated by sunlight. As the temperature rises, the compressive strength of geopolymer concrete rises as well. Under natural sunshine curing, significant compressive strength can be attained, although at a reduced fineness of fly ash. Higher fly ash fineness contributed to higher strength, but at a higher temperature. When compared to atmospheric temperature curing without the use of a traditional energy source, Solar Oven Curing produces excellent outcomes. As an outcome, the sun curing system will be a green endeavor.

In this [2] authors discussed the major goal of this research is to show how the parameters of geopolymer foams made in the same method change, which is linked to challenges in managing the foaming process. Controlling the foaming process of geopolymers is difficult, which is why they aren't widely used today. The findings revealed that geopolymers can be a good alternative to traditional insulation materials, but that the foaming technology needs to be increased so thatit is stable and allows for repeatable material parameters.

Fly ash-based foam geopolymer composites offer intriguing alternatives to conventional materials including polystyrene, mineral wool, and glass. They are a non-flammable substance with rather good insulating properties. This material is projected to be deployed on a large scale in the near as an alternative to the currently utilized insulating materials in building. However, additional research into the stability and repeatability of the generated geopolymer foams is required in order to prepare for application. It should also be a goal to make it possible to produce foamed inorganic polymers out of various waste materials.

In this [3] authors discussed a comprehensive overview of the technology, guidelines, applications, problems, and prospects of ongoing research and market in the construction industry, the authors reviewed the current technological, socioeconomical, and environmental elements related to 3DP of concrete structures. Researchers should investigate the issues of 3D concrete printing further in order to improve mechanical performance, durability, and sustainability, as well as set appropriate standard parameters for printing structures, according tothis comprehensive assessment.

Because 3DP gives undeniably high precision, is applicable to a wide range of materials, allowsfreedom in planning and constructing complicated structures, and has a low waste production record, it is gaining popularity. A thorough examination of the technology's present deployment in various locations, as well as the materials utilized for 3DP of concrete structures, was undertaken. Despite the numerous advantages, 3DP use in concrete structure construction posesmajor hurdles.

In this [4] authors discussed the ingredients of GPC were discussed, and their impact on GPC characteristics was evaluated critically. The qualities of GPC when it is new and when it has hardened, as well as the factors that determine these characteristics, are thoroughly investigated. It has been recommended that flow charts be used to show which factors have a higher or smallerimpact on the fresh and hardened properties of GPC. GPC admixture, researchers involved GPC, 3D printing with GPC, strengthened GPC, and global warming potential (GWP) evaluation were all thoroughly investigated. Finally, GPC applications in the construction industry are discussed

NaOH and Na_2SiO_3 are the most commonly utilized activators in GPC. Several parameters influence the development of the repolymerization reaction, including concentration, quantity, molarity, and reactivity. It is critical to determine the optimal activator dosage in the geopolymerblend in order to get increased mechanical and durability qualities. Furthermore, as compared to activators, it was discovered that soluble silicates have a faster geo polymerization reaction. Studies have been done to analyses mechanical qualities and durability characteristics depending on several aspects such as the NaOH/Na_2SiO_3 ratio, the NaOH/slag ratio, and the NaOH/slag ratio.

In this [5] authors discussed the current work shows how coal fly-ash can be used to make ultralightweight geopolymer foam aggregate. Sodium hydroxide (NaOH) and sodium silicate (Na_2SiO_3), both alkaline activators, were employed to activate fly ash, with Na_2SiO_3 also serving as a foaming agent. Sodium bicarbonate ($NaHCO_3$) was also used as a supplement for cementitious materials hardening and strength development increase. A standard curing method, microwave-oven curing, were employed as an alternative to traditional energy and moment curing processes to improve quick strength increase and sustainability of materials and technologies. To investigate if manufactured aggregates can be used to make super-duper foam, they were tested to natural and synthetic coarse aggregates. The findings revealed that produced aggregates have physic-mechanical qualities that make them appropriate for lightweight concretedesign, both structurally and thermally.

Fly ash was used to create ultralight foam aggregate (LGFA), which was then geo polymerized using sodium silicate acting as an alkaline activator and foaming agent. Furthermore, rapid curing was accomplished using microwave irradiation, which is a time-saving and energy-saving curing approach. The physical and mechanical properties of LGFA were investigated and compared to those of LWA manufactured using various curing procedures found in the literature. Although the mechanical strength of LGFA was harmed by its porous interior structure and was lower than that of other LWA in the literature, the discussion demonstrated that LGFA can be used to make foam concrete.

In this [6] authors discussed the three primary functional features of GFC covered in this review are mechanical quality, serviceability, and durability. The ingredients, foaming techniques, curing conditions, and additions determine the essential fresh and hardened qualities, and all of these characteristics are determined by the material properties, foam methods, curing circumstances, and additives. As an outcome, a complete explanation of these connections is provided, as well as suggestions for improving performance as a construction material. The difficulties of large-scale production and GFC deployment in the real world are also discussed.

Over the years, commendable efforts have been made in the development of new materials, methodologies, and optimization strategies. As determined by evaluating the research trend, outcomes, and genuine requirements, the following is an overview of current thinking, prospective viewpoints, and problems: To ensure an optimum foaming process that produces in maximum porosity and equally distributed finer pores, it's critical to maintain a continuous fresh GFC. Rheology and the setting/gelling of the base mix are the two main factors that impact the stability of fresh GFC.

In this [8] authors discussed the Geopolymers derived from solid wastes have a wide range of applications, including concrete, fireproof materials, impermeable materials, catalysts, adsorbents, and energy storage materials. Geopolymers, on the other hand, appear to be more effective at immobilizing heavy metals in solid waste. As an outcome, geopolymer might be shown to be a long-lasting, environmentally friendly "green product." However, solid wastes employed in geopolymer continue to be a problem. The government, businesses, and the general public must collaborate for co-governance in order to accomplish industrialization and commercialization of solid waste-based geopolymer.

When garbage is used as a biomass feedstock or as a supplementary cementitious material for the production of geopolymers, factors including such particle size, specific surface area, chemical composition, and mineralogical characteristics affect the solid waste's activity, which affects the geopolymer's reactivity and performance. To pick suitable solid waste components for the creation of geopolymers that meet performance criteria, strict quality control and testingare required. Even though no standard exists for determining the behavior and categorization of

In this [9] authors discussed the impact of reinforcement on the properties of geopolymer composites for 3D printing is discussed in this research, which focuses on geopolymer composites depend on fly ash reinforced with fibers. It compares the effectiveness of short and long fiber reinforcement, focusing on mechanical qualities such as flexural strength. Various composites are included in the comparison. The essay is depended on data from the literature as well as research undertaken in the context of two projects. The first, titled "Development of eco-friendly composite materials depend on geopolymer matrix and reinforced with waste fibers," is being carried out in the ERA Net-LAC as part of an international partnership.

Low labor costs, minimal waste, and high efficiency are all advantages of geopolymer 3D printing technology. Unfortunately, their use is limited; only a few prototype pieces have been carried out using this technology. Geopolymers, the material, still needs to be developed and optimized. The fiber reinforcing of 3D printed geopolymers is a viable technique to generate materials that may be used in large-scale manufacturing. In many applications, this could be a viable substitute to concrete. Development of ambient temperature cured geopolymers, development of printed technology for foamed geopolymers, and designing of nonadditive such as nano clay is some of the other potential directions that could be supplementary to fiber reinforced geopolymers for 3D printing.

In this [10] authors discussed the development, testing, and production of new panels made up of two layers of high-strength fiber-reinforced concrete sandwiched between two layers of high- performance insulation. In order to achieve composite action, the layers are joined via fiber reinforced polymer grid connectors. When compared to typical reinforced concrete panels, thin precast concrete sandwich panels save weight and material, allowing for increased production, transportation, and onsite efficiency, as well as lower embodied energy. Many recent studies on reducing the thickness of concrete sections have emphasized the use of textile reinforced concrete, which demands specific equipment and manufacturing techniques. Instead, this work

In this [11] authors discussed a promising alternative adsorbent, geopolymer, is being developed for the removal of heavy metal contaminants from water using adsorption techniques. Because it may be made from waste and by-products, geopolymer adsorbent can be considered a sustainable material. The fabrication method, removal capability, and factors affecting geopolymer removal ability have also been highlighted. Because binding site is such an important criterion for adsorption, improvements in adsorbent porosity, i.e. porous and pervious geopolymer, as well as varied geopolymer shapes, all of which influence the available binding sites, are discussed. The objective of this analysis is to present the most up-to-date information on geopolymer technology for removing heavy metal pollution from water.

In this [12] authors discussed the impact of the solid precursor on the definition, chemistry, processing, and applications of geopolymers is explored in this journal. The intrinsic nature and properties of the aluminosilicate precursors are shown to regulate the procedure, the alkaline solution, the curing conditions, and the orientation of the end-products in terms of performance and prospective application. The geo polymerization is governed by the amorphous percentage as well as the accessible Al and Si cations. Solid precursors containing a significant amount of amorphous phase can be easily activated with a standard alkaline solution, resulting in the development of a gel known as cement or binder. Al-rich gels can be used to create high-strength concrete or composites. Solid precursors with a low amorphous percentage, such as fly ash, volcanic ash, feldspars, granites, nepheline, and other aluminosilicates with a high fraction of crystalline phases, require a relatively high concentrated alkaline solution. Both the dissolving and cure phases in these circumstances demand a temperature higher than ambient.

Conclusion

In the present work, the main emphasis was given to explore theuse of waste materials such as fly ash on the various properties of concrete when used singly or in combination.

REFERENCES

[1].Akhtar, Naveed, S. V. Patankar, S. S. Jamkar, Faizan Ahmed, and Saud Mahvi. "Effect of Different Curing Systems on Strength Characteristics of Geopolymer Concrete." (2020).

[2].Łach, Michał, Janusz Mikuła, Lin Wei-Ting, Patrycja Bazan, Beata Figiela, and Kinga Korniejenko. "Development and characterization of thermal insulation geopolymer foams based on fly ash." Proceedings of Engineering and Technology Innovation 16 (2020): 23.

[3].Siddika, Ayesha, Md Abdullah Al Mamun, Wahid Ferdous, Ashish Kumer Saha, and Rayed Alyousef. "3D-printed concrete: Applications, performance, and challenges." Journal of Sustainable Cement-Based Materials 9, no. 3 (2020): 127-164. [4].Imtiaz, Lahiba, Sardar Kashif Ur Rehman, Shazim Ali Memon, Muhammad Khizar Khan, and Muhammad Faisal Javed. "A review of recent developments and advances in eco- friendly geopolymer concrete." Applied Sciences 10, no. 21 (2020): 7838.

[5].Hanif, Sadia, Muhammad Akram Tahir, Khuram Rashid, Munib Ul Rehman, Nimra Saleem, Aamna Aslam, and Ghinwa Naeem. "Physico-mechanical performance of lightweight geopolymer foam aggregates developed by geopolymerization through microwave-oven irradiations." Journal of King Saud University-Engineering Sciences (2021).

[6].Dhasindrakrishna, K., Kirubajiny Pasupathy, Sayanthan Ramakrishnan, and Jay Sanjayan. "Progress, current thinking and challenges in geopolymer foam concrete technology." Cement and Concrete Composites 116 (2021): 103886.

[7].Santana, Henrique A., Nilson S. Amorim Júnior, Daniel V. Ribeiro, Marcelo S. Cilla, and Cleber MR Dias. "3D printed mesh reinforced geopolymer: Notched prism bending." Cement and Concrete Composites 116 (2021): 103892.

[8].Ren, Bo, Yunliang Zhao, Haoyu Bai, Shichang Kang, Tingting Zhang, and Shaoxian Song. "Eco-friendly geopolymer prepared from solid wastes: A critical review." Chemosphere 267 (2021): 128900.

[9].Korniejenko, Kinga, and Michał Łach. "Geopolymers reinforced by short and long fibres–innovative materials for additive manufacturing." Current Opinion in Chemical Engineering 28 (2020): 167-172.

[10]. O'Hegarty, Richard, Oliver Kinnane, Michael Grimes, John Newell, Michael Clifford, and Roger West. "Development of thin precast concrete sandwich panels: Challenges andoutcomes." Construction and Building Materials 267 (2021): 120981.

[11]. Tan, Tee How, Kim Hung Mo, Tung-Chai Ling, and Sai Hin Lai. "Current development of geopolymer as alternative adsorbent for heavy metal removal." Environmental Technology & Innovation 18 (2020): 100684.

[12]. Kamseu, Elie, Valeria Alzari, Daniele Nuvoli, Davide Sanna, Isabella Lancellotti,Alberto Mariani, and Cristina Leonelli. "Dependence of the geopolymerization process andend- products to the nature of solid precursors: Challenge of the sustainability." Journal of Cleaner Production 278 (2021): 123587.

[13]. Zakka, Wyom Paul, Nor Hasanah Abdul Shukor Lim, and Ma Chau Khun. "A scientometric review of geopolymer concrete." Journal of Cleaner Production 280 (2021):124353.

[14]. Luhar, Salmabanu, Ismail Luhar, and Faiz Uddin Ahmed Shaikh. "Review on Performance Evaluation of Autonomous Healing of Geopolymer Composites." Infrastructures 6, no. 7 (2021): 94.

[15].Singh, N. B., and B. Middendorf. "Geopolymers as an alternative to Portland cement: An overview." Construction and Building Materials 237 (2020): 117455.

[16]. Nodehi, Mehrab. "A comparative review on foam-based versus lightweight aggregate- based alkali-activated materials and geopolymer." Innovative Infrastructure Solutions 6, no. 4 (2021): 1-20.

[17]. Nodehi, Mehrab. "A comparative review on foam-based versus lightweight aggregate- based alkali-activated materials and geopolymer." Innovative Infrastructure Solutions 6, no. 4 (2021): 1-20.

[18]. Ojha, Avinash, and Praveen Aggarwal. "Fly Ash Based Geopolymer Concrete: a Comprehensive Review." Silicon (2021): 1-20.