International Journal of Engineering, Science and Mathematics
Vol. 12 Issue 6, June 2023,
ISSN: 2320-0294 Impact Factor: 6.765
Journal Homepage: http://www.ijesm.co.in, Email: editorijmie@gmail.com
Double-Blind Peer Reviewed Refereed Open Access International Journal - Included in the International Serial Directories Indexed & Listed at: Ulrich's Periodicals Directory ©, U.S.A., Open J-Gage as well as in Cabell's Directories of Publishing Opportunities, U.S.A

A Review of Fly Ash-Based Geopolymer and the Utilization of Plastic E-Waste

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ABSTRACT

This review provides a comprehensive analysis of fly ash-based geopolymer and the utilization of plastic e-waste in construction applications. Fly ash-based geopolymer is an emerging and sustainable alternative to traditional cement-based materials, offering reduced environmental impact and enhanced mechanical properties. The review explores the composition, manufacturing process, and performance characteristics of fly ash-based geopolymer, including its compressive strength, durability, and resistance to various environmental factors. Furthermore, the review investigates the potential utilization of plastic e-waste as a supplementary material in geopolymer composites. Plastic e-waste, derived from discarded electronic products, poses significant environmental challenges. However, by incorporating plastic e-waste into geopolymer matrices, it can serve as a valuable resource, enhancing the properties of the geopolymer and promoting the circular economy. The review critically evaluates the existing literature, highlighting the advantages and limitations of fly ash-based geopolymer and the incorporation of plastic e-waste. The influence of different factors, such as fly ash content, alkaline activators, curing conditions, and plastic e-waste particle size, on the mechanical and environmental performance of geopolymer composites is thoroughly examined.

INTRODUCTION

The construction industry is witnessing a growing demand for sustainable and eco-friendly building materials that minimize environmental impact and promote resource efficiency. In this context, fly ash-based geopolymer and the utilization of plastic e-waste have emerged as innovative approaches with the potential to address these challenges.

Fly ash-based geopolymer is an alternative to conventional cement-based materials, offering improved mechanical properties, reduced carbon emissions, and enhanced durability. Geopolymers are formed through the chemical reaction between fly ash, an industrial byproduct generated from coal combustion in power plants, and alkaline activators. This reaction produces a three-dimensional network of polymeric compounds, resulting in a binder with cementitious properties. Fly ash-based geopolymers have gained significant attention due to their low environmental impact and the ability to utilize large quantities of fly ash, thereby reducing waste disposal and conserving natural resources.

Plastic e-waste, on the other hand, presents a significant environmental challenge due to its non-biodegradable nature and harmful effects on ecosystems. However, recent research has explored the potential of incorporating plastic e-waste as a supplementary material in geopolymer composites. This approach not only addresses the issue of plastic waste management but also enhances the properties of geopolymer materials. Plastic e-waste, when properly processed and incorporated into the geopolymer matrix, can contribute to improved mechanical strength, reduced density, and enhanced thermal and acoustic insulation properties.

This review aims to provide a comprehensive analysis of fly ash-based geopolymer and the utilization of plastic e-waste in construction applications. It explores the composition, manufacturing process, and performance characteristics of fly ash-based geopolymer, including its compressive strength, durability, and resistance to environmental factors. Additionally, it examines the potential benefits and challenges associated with incorporating plastic e-waste in geopolymer composites, highlighting the influence of different parameters on the mechanical and environmental performance of these materials.

By critically reviewing the existing literature, this review aims to identify the gaps and limitations in current research and provide insights for future investigations. The findings of this review will contribute to a deeper understanding of fly ash-based geopolymer technology and the potential of plastic e-waste as a sustainable construction material. Ultimately, the utilization of fly ash-based geopolymer and plastic e-waste has the potential to revolutionize the construction industry by offering environmentally friendly alternatives and promoting circular economy principles.

SCOPE OF THE RESESRCH

The scope of the research on fly ash-based geopolymer and the utilization of plastic e-waste is multifaceted, covering various aspects related to their composition, manufacturing process, properties, and applications in the construction industry. The research aims to provide a comprehensive understanding of the potential benefits, challenges, and opportunities associated with these innovative approaches.

The scope includes investigating the optimal proportions of fly ash, alkaline activators, and other additives in geopolymer formulations. It involves exploring different methods of synthesizing geopolymer materials, including mixing techniques, curing conditions, and curing durations. The research also focuses on examining the effects of incorporating plastic e-waste, such as particle size, content, and pre-treatment methods, on the geopolymer matrix.

The research scope encompasses evaluating the mechanical properties, such as compressive strength, flexural strength, and modulus of elasticity, of fly ash-based geopolymer composites. It includes assessing the durability performance of geopolymer materials, including resistance to moisture, chemical attack, and thermal cycling. The research also involves investigating the microstructure and pore characteristics of geopolymer matrices using techniques like SEM (Scanning Electron Microscopy) and XRD (X-ray Diffraction).

Additionally, the scope extends to analyzing the effects of incorporating plastic e-waste on the mechanical, thermal, and acoustic properties of geopolymer materials. It includes studying the compatibility between plastic e-waste and the geopolymer matrix to ensure adequate bonding and structural integrity. The research also aims to assess the long-term behavior and stability of geopolymer composites containing plastic e-waste.

The scope further encompasses exploring potential applications of fly ash-based geopolymer and plastic e-waste composites in construction, such as bricks, blocks, panels, and pavement materials. It involves assessing the environmental impact and sustainability aspects of these materials, including carbon footprint reduction and waste management benefits. The research also considers the economic feasibility and scalability of implementing fly ash-based geopolymer and plastic e-waste technologies in the construction industry.

PROBLME STATEMENT

The construction industry faces significant challenges in terms of environmental impact, resource depletion, and waste management. Traditional cement-based materials contribute to high carbon emissions and rely on finite natural resources. Additionally, plastic e-waste poses a significant environmental problem due to its non-biodegradable nature and harmful effects on ecosystems.

There is a need to address these challenges by exploring sustainable alternatives and innovative solutions. Fly ash-based geopolymer offers a promising alternative to conventional cement-based materials, utilizing a waste product (fly ash) and reducing carbon emissions. However, there are still limitations and gaps in the understanding of its optimal composition, manufacturing process, and performance characteristics.

Furthermore, plastic e-waste presents an opportunity for resource utilization and waste management. Incorporating plastic e-waste into geopolymer composites can potentially enhance the properties of the materials, but there is a lack of comprehensive research on the effects of different parameters and the long-term behavior of these composites.

Cement and Concrete with Fly Ash

Cement and concrete with fly ash offer significant benefits in terms of sustainability and performance. Fly ash, a byproduct of coal combustion in power plants, is commonly used as a partial replacement for cement in concrete production. The addition of fly ash enhances the workability, durability, and strength of concrete while reducing carbon emissions. It improves the long-term performance of concrete structures, enhances resistance to cracking, and reduces the heat of hydration. Moreover, the utilization of fly ash reduces the demand for traditional cement, conserves natural resources, and mitigates environmental impacts. Cement and concrete with fly ash play a vital role in sustainable construction practices.

Fly Ash

Fly ash is a fine, powdery material that is produced as a byproduct during the combustion of pulverized coal in thermal power plants. It is collected from the exhaust gases by electrostatic precipitators or baghouses, making it an abundant and readily available resource. Fly ash consists of small spherical particles, primarily composed of silicon dioxide (SiO_2), aluminum oxide (Al_2O_3), and iron oxide (Fe_2O_3), along with traces of calcium, magnesium, and other elements. In recent years, fly ash has gained significant attention in the construction industry due to its various beneficial properties and environmental advantages. One of its key uses is as a partial replacement for cement in concrete production. By substituting a portion of cement with fly ash, the environmental impact of concrete is reduced, as fly ash is a waste material that would otherwise be disposed of in landfills. The addition of fly ash to concrete offers several advantages. Firstly, fly ash improves the workability of concrete, making it easier to mix and place. It acts as a lubricant, reducing the water demand and increasing the flowability of the mixture. This property is particularly beneficial for large-scale construction projects where the efficient and timely placement of concrete is crucial.

Fly ash enhances the long-term durability and strength of concrete. It contributes to the formation of additional cementitious compounds, resulting in denser and more impermeable concrete. This improved density reduces the ingress of harmful substances, such as chlorides and sulfates, which can cause corrosion of reinforcing steel and degradation of the concrete over time.

Furthermore, fly ash has pozzolanic properties, meaning that it reacts with calcium hydroxide in the presence of water to form additional cementitious compounds. This reaction continues over time, providing long-term strength development and improved performance of concrete structures.

LITERATURE REVIEW

Partheeban, P et al (2021) Performance evaluation of geopolymer concrete using E-waste involves assessing the mechanical, durability, and environmental properties of the concrete to determine its suitability for construction applications. Geopolymer concrete is an innovative and sustainable alternative to conventional Portland cement-based concrete, utilizing fly ash or other aluminosilicate materials as binders and alkaline activators. The inclusion of E-waste in geopolymer concrete aims to address the growing problem of electronic waste and explore its potential as a supplementary material. E-waste, such as discarded printed circuit boards, can be processed and incorporated into the geopolymer matrix to enhance certain properties of the concrete. Mechanical properties, including compressive strength, flexural strength, and tensile strength, are crucial for evaluating the structural performance of geopolymer concrete with E-waste. Testing these properties helps determine the load-bearing capacity and structural integrity of the material. Comparisons can be made between geopolymer concrete with and without E-waste to assess the influence of E-waste on mechanical strength.

Verma, P (2022) The potential assessment of E-waste plastic in metakaolin-based geopolymer involves evaluating the suitability and performance of incorporating E-waste plastic particles into geopolymer matrices using metakaolin as a binder. Geopolymer materials offer an eco-friendly alternative to traditional cement-based materials by utilizing industrial byproducts and reducing carbon emissions.The assessment begins with the characterization of E-waste plastic particles, including their size, shape, composition, and compatibility with the metakaolin-based geopolymer system. Different pre-treatment methods, such as cleaning, shredding, and sieving, may be employed to optimize the properties of the E-waste plastic particles for incorporation into the geopolymer matrix. The mechanical properties of the metakaolin-based geopolymer composites with E-waste plastic, such as compressive strength, flexural strength, and tensile strength, are evaluated to assess the structural performance of the material. The influence of the E-waste plastic content and particle size distribution on the mechanical properties is examined to determine the optimal formulation. the durability of the geopolymer composites is assessed, considering factors such as resistance to moisture absorption, chemical attack, and thermal cycling. Special attention is given to the potential interactions between the E-waste plastic particles and the geopolymer matrix, which may affect the durability properties of the material. Accelerated aging tests and exposure to harsh environmental conditions can provide insights into the long-term behavior and stability of the composites.

Sundar, M. L., & Raj, S. (2017). A study on the characteristics of geopolymer concrete with E-waste focuses on understanding the properties and performance of geopolymer concrete when E-waste materials are incorporated into the mixture. Geopolymer concrete is an eco-friendly alternative to traditional cement-based concrete, utilizing industrial byproducts and reducing carbon emissions. The study begins with the selection and characterization of E-waste materials, such as discarded electronic components or printed circuit boards. The E-waste materials are processed and prepared for incorporation into the geopolymer concrete mixture. Factors like particle size, shape, and composition of the E-waste materials are analyzed to assess their suitability for geopolymer concrete production. The geopolymer concrete mixture is designed by replacing a portion of the conventional aggregates or binder materials with the E-waste materials. The effects of varying E-waste content, particle size distribution, and processing techniques on the fresh and hardened properties of the geopolymer concrete are investigated. The fresh properties of geopolymer concrete with E-waste, including workability, slump, and setting time, are assessed to ensure that the mixture can be properly placed and compacted. The influence of E-waste content on these properties is examined to determine the optimal E-waste dosage for practical application.

Chandan Kumar et al (2020) The utilization of e-waste in geopolymer concrete through the partial replacement of coarse aggregate involves incorporating e-waste materials into the concrete mixture to replace a portion of the conventional coarse aggregates. Geopolymer concrete is an environmentally friendly alternative to traditional Portland cement-based concrete, utilizing industrial byproducts and reducing carbon emissions. In this approach, e-waste materials such as discarded electronic components or printed circuit boards are selected, processed, and prepared for use as a partial replacement for coarse aggregates. The e-waste materials are typically crushed, sieved, and cleaned to remove any contaminants or hazardous substances. The concrete mixture is designed by replacing a certain percentage of the conventional coarse aggregates with the processed e-waste materials. The replacement level may vary depending on the desired properties and requirements of the geopolymer concrete. The impact of incorporating e-waste as a partial replacement for coarse aggregate is evaluated in terms of the fresh and hardened properties of the geopolymer concrete. The fresh properties, including workability, slump, and setting time, are assessed to ensure that the mixture can be properly placed and compacted. Adjustments may be made to the mix design and water-to-binder ratio to maintain the desired workability.

CONCLUSION

In conclusion, the review of fly ash-based geopolymer and the utilization of plastic e-waste presents a promising avenue for sustainable construction practices. Fly ash-based geopolymer offers a viable alternative to conventional cement-based materials, utilizing fly ash waste and reducing carbon emissions. The incorporation of plastic e-waste in geopolymer composites provides a solution for waste management and enhances the properties of the materials, promoting resource efficiency and the circular economy.

Through a comprehensive analysis of the existing literature, several key findings and conclusions have emerged. Firstly, the optimal composition and manufacturing process of fly ash-based geopolymer require careful consideration. The proportions of fly ash, alkaline activators, and additives significantly impact the mechanical properties and durability of the geopolymer. Further research is needed to optimize the formulation and manufacturing techniques for achieving desired performance characteristics.

The utilization of plastic e-waste in geopolymer composites shows promise in improving the mechanical properties and reducing the density of the materials. However, the compatibility between plastic e-waste and the geopolymer matrix needs to be carefully assessed to ensure adequate bonding and structural integrity. Furthermore, the long-term behavior and stability of geopolymer composites containing plastic e-waste require thorough investigation to ensure their performance over time.

The review highlights the importance of comprehensive performance characterization of fly ash-based geopolymer and geopolymer composites with plastic e-waste. Mechanical properties such as compressive strength, flexural strength, and modulus of elasticity, as well as durability aspects including resistance to moisture, chemical attack, and thermal cycling, should be systematically evaluated. This will provide a better understanding of their behavior under different environmental conditions and enable their reliable application in construction.

Additionally, the review emphasizes the significance of considering the environmental sustainability of fly ash-based geopolymer and plastic e-waste utilization. Life cycle assessments, carbon footprint analyses, and economic feasibility studies are crucial to assess the overall environmental impact and economic viability of these materials. The circular economy concept should be integrated into the design and production processes, ensuring the efficient use of resources and minimizing waste generation.

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