"Physical and mechanical properties of concrete using waste powder material as partial cement replacement"

By

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Such as the requirement for conversion of engineering rank from **authorized** to **consultant**

Abstract

Recycling, a process of repurposing used materials for new products, is crucial in addressing the escalating concerns surrounding the growing waste from construction projects. The environmental impact of waste accumulation, often illegally discarded or used as landfill material, has prompted the exploration of eco-friendly alternatives. Scholars advocate for the incorporation of waste materials as partial replacements for normal aggregate in concrete, a prevalent construction material globally,

This scientific report explores the physical and mechanical properties of concrete when waste powder material is employed as a partial replacement for traditional cement. By investigating the structural characteristics and durability of the resulting concrete, the study aims to contribute valuable insights into sustainable construction practices. The research emphasizes the potential environmental benefits, including reduced carbon emissions and enhanced resource conservation, aligning with the growing imperative for eco-friendly building materials.

Keywords: Waste powder material, Cement replacement, Physical properties, Mechanical properties, Sustainable development and Environmental impact

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CHAPTER 1 Introduction:

1.1 Introduction:

Sustainable construction practices have emerged as a critical imperative in contemporary civil engineering, driven by the urgent need to reconcile infrastructure development with environmental responsibility. Traditional construction methods, particularly those reliant on resource-intensive materials like Portland cement, contribute significantly to carbon emissions and resource depletion. In response to this, the construction industry is increasingly turning towards sustainable alternatives that mitigate environmental impact without compromising structural integrity.

This paradigm shift is underscored by a commitment to balance economic growth with ecological conservation, meeting the needs of the present without compromising the ability of future generations to meet their own needs. One such avenue of exploration is the incorporation of waste materials into construction processes. This research specifically addresses the integration of waste powder material as a partial replacement for cement in concrete—a promising avenue for reducing the carbon footprint associated with cement production and disposal of waste materials.

Understanding the physical and mechanical properties of concrete when augmented with waste powder is pivotal not only for optimizing construction materials but also for advancing the broader cause of sustainable development. This study contributes to this evolving field by shedding light on the potential benefits and challenges associated with this eco-friendly alternative, providing valuable insights for the construction industry as it navigates towards a more sustainable and resilient future .

1.2 Aims:

This study examines how waste powder material, as a partial substitute for cement, influences the physical and mechanical properties of concrete, offering insights into sustainable construction practices and Environmental impacts .

CHAPTER 2 Waste powder material and Cement replacement:

Waste powder material refers to residual or unused fine, granular substances generated as byproducts in various industrial processes. This type of waste typically consists of powdered or particulate matter resulting from activities like manufacturing, machining, or other production processes. Examples include metal powders, plastic granules, or leftover materials from processes like 3D printing.

Waste powder materials may pose environmental challenges if not managed properly. Effective waste management strategies involve recycling or proper disposal methods to minimize their impact on the environment. In certain cases, these powders can be repurposed or recycled to reduce overall waste generation and promote sustainability in industrial practices.

2.1 Fly Ash: A by-product of coal combustion, fly ash is a pozzolanic material that can be used to partially replace cement in concrete mixes. One of the primary applications of fly ash is as a supplementary cementations material in concrete. It can replace a portion of the cement in concrete mixes, the use of fly ash in concrete can enhance workability, reduce heat of hydration, and improve resistance to certain chemical attacks. Incorporating fly ash in concrete offers several benefits, including increased strength, improved durability, reduced permeability, and better resistance to sulphate and alkali-aggregate reactions. It also contributes to the mitigation of greenhouse gas emissions associated with cement production. Recycling fly ash in concrete is considered environmentally friendly because it reduces the need for disposal in landfills, thereby minimizing the environmental impact of coal combustion by-products

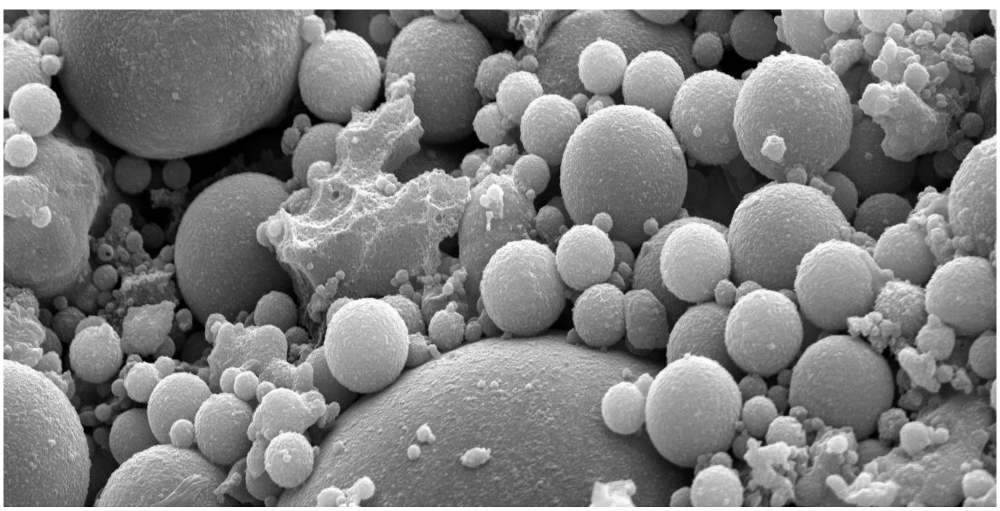


Figure 1 . fly ash particle

2.2 Recycled Plastic: The use of recycled plastic in concrete aligns with the broader goals of sustainable construction practices, circular economy principles, and efforts to minimize the environmental impact of the construction industry. As technology and research in this area progress, the application of recycled plastic in construction materials may become more widespread.he addition of recycled plastic can impact the strength and durability of concrete. While it may not replace cement entirely, it can serve as a partial replacement. The specific properties depend on factors such as the type of plastic, its particle size, and the concrete mix design.

The workability and flow characteristics of concrete can be influenced by the inclusion of recycled plastic. Adjustments to the concrete mix may be necessary to maintain desired performance.

Ensuring compatibility between the recycled plastic and the other concrete components is crucial. The plastic should not adversely affect the setting, hardening, or long-term performance of the concrete.

Figure 2. Oft-Plastics-SVC-Polyrok2

2.3 Rice Husk Ash (RHA):

Rice husk ash (RHA) is a by-product obtained from the burning of rice husks, which are the outer protective coverings of rice grains. When rice husks are burned, the organic material combusts, leaving behind ash. This ash is rich in silica and possesses pozzolanic properties, making it suitable for use as a supplementary cementations material in concrete.

Silica Content: RHA is predominantly composed of amorphous silica. The high silica content contributes to its pozzolanic reactivity.

Pozzolanic Properties: Like other pozzolanic materials, RHA reacts with calcium hydroxide (produced during the hydration of cement) to form additional cementations compounds. This reaction improves the strength and durability of concrete.

Partial Replacement for Cement: RHA can be used as a partial replacement for cement in concrete mixes. The substitution of cement with RHA helps reduce the overall amount of cement used in concrete, contributing to sustainability efforts in the construction industry.

Strength Enhancement: Incorporating RHA into concrete has been found to enhance compressive strength, especially at later ages. It can also improve other mechanical and durability properties of concrete.

Advantages of Using RHA in Concrete:

Reduced Environmental Impact: Utilizing RHA in concrete reduces the demand for traditional cement, which is energy-intensive to produce. This contributes to a reduction in carbon dioxide emissions associated with cement manufacturing.

Figure 3. Rice-husk-ash

2.4 Glass Powder: Finely ground waste glass, often obtained from recycled bottles or other glass products, can be used as a partial cement replacement. This not only reduces the environmental impact of glass disposal but also enhances certain properties of concrete.

Waste glass is typically used as a partial replacement for cement in concrete mixes. The percentage of cement replaced by waste glass can vary depending on factors such as the desired concrete properties, the type of glass, and specific project requirements.

n certain cases, waste glass can contribute to improved compressive strength of concrete. This enhancement may be attributed to the pozzolanic reactions and the filler effect of finely ground glass particles.

Waste glass can enhance the durability of concrete by reducing permeability and improving resistance to certain chemical attacks, such as alkali-silica reaction.

Concrete incorporating waste glass can be used in various construction applications, including pavements, sidewalks, and building structures.

Architectural Elements: The aesthetic qualities of glass particles can also be leveraged in architectural concrete elements, providing a unique appearance to the finished product.

Figure 4. Waste-glass-powder

CHAPTER 3 Physical Properties:

3.1 Density:

Density is a critical factor influencing both the physical and mechanical properties of concrete when waste powder materials are used as partial cement replacements. Incorporating these materials can impact the overall density of the concrete, affecting properties such as strength and durability. Careful consideration of mix proportions and material characteristics is essential to maintain desired density levels, ensuring optimal performance in sustainable concrete construction.

The density of concrete, influenced by partial cement replacement with waste powder materials, plays a pivotal role in shaping its physical and mechanical properties. This includes effects on compressive strength, durability, and overall performance. Controlling the mix design is crucial to strike a balance between incorporating sustainable materials and maintaining the desired density for optimal concrete characteristics.

3.2 Porosity:

Porosity in concrete refers to the presence of void spaces or pores within the material. It plays a crucial role in determining the physical and mechanical properties of concrete. The level of porosity affects several key aspects, including durability, permeability, and strength.

Using waste powder material as a partial cement replacement, understanding and managing porosity become especially important. The incorporation of waste powder materials can influence the porosity of the concrete matrix. Properly designed mixtures can result in reduced porosity, enhancing the overall performance of the concrete.

Reducing porosity can lead to improved durability by minimizing the ingress of harmful substances, such as water, chemicals, and gases. This, in turn, enhances the resistance of the concrete to deterioration processes like corrosion of reinforcement.

Additionally, the mechanical properties of concrete, such as compressive strength and tensile strength, are influenced by porosity. Higher porosity generally corresponds to lower strength, so managing and optimizing porosity levels are crucial for achieving the desired mechanical performance.

Physical and mechanical properties of concrete using waste powder material should consider the impact of porosity on durability and strength. Controlling porosity through proper material selection and mix design is key to developing sustainable and high-performance concrete mixes.

3.3 Absorption:

Absorption in the context of concrete refers to the capacity of the material to take in and retain water. It is a critical factor in understanding the physical and mechanical properties of concrete, particularly when incorporating waste powder material as a partial cement replacement.

The absorption characteristics of concrete can be influenced by the types and proportions of materials used in the mix. When waste powder materials are introduced as partial cement replacements, their absorption behaviour becomes a crucial consideration. Properly managing absorption is essential to control the overall porosity of the concrete.

Understanding the absorption properties of concrete is vital for assessing its durability, as excessive water absorption can lead to various issues such as increased permeability, freeze-thaw damage, and chemical attack. By optimizing the mix design, it is possible to minimize absorption and enhance the resistance of concrete to environmental factors.

3.4 Setting Time:

The addition of waste powder material may influence the setting time of the concrete. Changes in setting time can impact construction processes, such as placement, finishing, and form removal. It's essential to investigate how different proportions of waste powder affect the setting time and whether any adjustments to the mix design or construction practices are necessary.

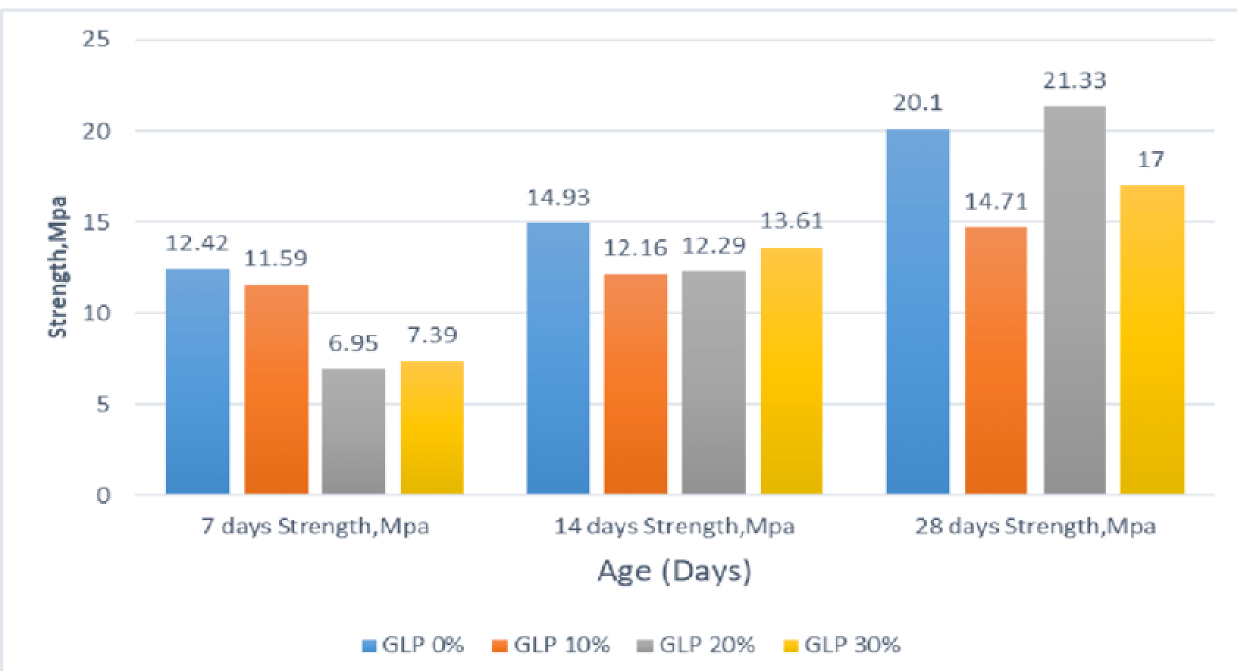
The initial and final setting times of concrete mixes with varying levels of waste powder material.

Setting time is a practical consideration when using waste powder material in concrete mixes. Assessing and understanding the setting time variations will contribute to the successful implementation of concrete with waste powder as a partial cement replacement in construction applications.

CHAPTER 4 Mechanical properties:

4.1 Compressive Strength:

Fig. is showing the comparison of compressive strength of concrete with different percentages of waste glass powder (GLP). Using 10% of GLP, the compressive strength at 7 days was nearly about of plain concrete but at 14 days and 28 days, the strengths were not much increased and were remained almost stagnant. Using 20% of GLP, the compressive strength at 7 days and 14 days were much lower than of plain concrete but at 28 days, the strengths was increased marginally and the compressive strength was more than that of plain concrete. Using 30% of GLP, the compressive strength at 7 days was much lower than of plain concrete but at 14 days, the strength was nearly about of plain concrete and at 28 days, the strength was 15% lower than plain concrete.



4.2 Tensile Strength:

Fig. is showing the comparison of split tensile strength of concrete with different percentages of waste GLP. Using 10% of GLP, the splitting tensile strength at 7 days and 14 days were nearly about of plain concrete but at 28 days, the splitting tensile strength was slightly lower than that of plain concrete. Using 20% of GLP, split tensile strength at 7 days was slightly lower than that of plain concrete but at 14 days, the strength was increased marginally and the split tensile strength was more than 154 Experimental Investigation of Concrete with Glass Powder as Partial Replacement of Cement that of plain concrete. At 28 days, the split tensile strength was slightly lower than that of plain concrete. Using 30% of GLP, split tensile strength at 7 days was much lower than of plain concrete but at 14 days and 28 days, the strength was significantly increased and the strengths were more than plain concrete.

CHAPTER 5 Sustainable development and environmental impact:

The use of waste powder materials as a partial replacement of cement in concrete is a sustainable approach that addresses environmental concerns associated with traditional concrete production. This practice contributes to sustainable development by reducing the environmental impacts of construction activities. Here is a discussion on sustainable development and the impact on the environment when waste powder materials are used as partial replacements for cement:

5.1 Resource Conservation:

Using waste powder material as a cement replacement helps conserve resources by reducing the need for new raw materials. This aligns with sustainable development principles, minimizing the depletion of natural resources.

5.2 Waste Reduction:

Showcase the role of waste powder material in waste reduction and management. Utilizing industrial byproducts or recycled materials helps divert waste from landfills, addressing environmental concerns and promoting a circular economy.

5.3 Energy Savings:

Utilizing waste powder material in concrete production may lead to energy savings, as the manufacturing process for such waste materials often requires less energy compared to traditional cement production. This contributes to a more sustainable and eco-friendly concrete manufacturing process.

5.4 Reduced Carbon Footprint:

By incorporating waste powder material in concrete production, we can mitigate carbon emissions. Traditional cement production is a major contributor to CO_2 emissions, and using waste powder as a partial replacement helps decrease the overall carbon footprint of concrete production.

5.5 Economic Benefits:

Incorporating waste powder material in construction projects can offer economic advantages, potentially leading to cost savings. If the waste material is readily available or obtained at a lower cost than traditional cement, it can contribute to more budget-friendly construction projects.

5.6 Extended Service Life:

The use of waste powder material in concrete enhances its physical and mechanical properties, promoting longer service life for structures. This aligns with sustainability goals by reducing the necessity for frequent repairs and reconstructions, emphasizing durability and longevity.

5.7 Promotion of Sustainable Practices:

Adopting waste powder material in construction aligns with broader sustainable practices in the industry. This move towards environmentally friendly methods contributes to the promotion and adoption of sustainable construction practices, reflecting a commitment to reducing environmental impact and promoting more eco-friendly building processes.

5.8 Air Quality Improvement:

Using waste powder material in concrete production has positive effects on air quality. Traditional cement production can release pollutants into the air, contributing to air pollution. By incorporating waste powder as a substitute, the concrete manufacturing process becomes cleaner, reducing the environmental impact and minimizing air pollution associated with traditional cement production.

5.9 Water Conservation:

Absolutely, the utilization of waste powder material in concrete, if less water-intensive compared to traditional cement production, can contribute significantly to sustainable water management practices.

5.10 Landfill Diversion:

Incorporating waste powder material into concrete addresses the issue of landfill diversion by redirecting materials that might otherwise end up in landfills. This practice helps mitigate the environmental impact of waste disposal, promoting a more sustainable and eco-friendly approach to managing construction-related materials.

5.11 Ecological Impact:

Using waste powder material instead of extracting raw materials for concrete production can have a positive ecological impact. Extracting raw materials often involves habitat disruption and biodiversity loss. By opting for waste materials, the need for new extraction is reduced, contributing to biodiversity conservation and habitat preservation. This approach aligns with sustainable practices, minimizing the environmental footprint associated with traditional resource extraction for construction purposes.

Conclusion:

Concrete is experiencing notable advancements in sustainable development, evident in the industry's concerted efforts to manage CO2 emissions and mitigate the environmental impact of cement production. Research on supplementary cementing materials, often sourced from waste products, demonstrates the positive influence on concrete mix design, enhancing durability and strength for greater sustainability and cost-effectiveness. Concurrently, experimental work on waste powdered materials, Despite an increase in water absorption with higher waste material content,offering a sustainable alternative in producing modified reactive powder concrete.

In conclusion, these findings collectively underscore a commitment to redefining the role of concrete in sustainability. The integration of waste materials into concrete mix designs, coupled with advancements in production processes, positions concrete as a versatile, environmentally friendly, and economically viable construction material. The ongoing pursuit of sustainability in the concrete industry reflects a dedicated effort to make concrete a more efficient and eco-friendly option for construction projects on a global scale.

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