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Demolished Waste and RHA Based Cement Concrete: A Review

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Abstract
In recent years, the global construction industry has experienced rapid growth, resulting in increased urbanization, infrastructure expansion, and a rise in building activities. While these developments drive economic progress, they also introduce significant environmental concerns, particularly regarding the disposal of construction and demolition waste. A substantial fraction of this waste consists of demolished concrete, which, if not properly managed, can lead to serious environmental hazards. The improper disposal of demolished concrete exacerbates landfill congestion, causes soil contamination, and contributes to greenhouse gas emissions, further intensifying climate change-related challenges. Addressing these issues has become a priority, encouraging researchers and industry experts to explore sustainable alternatives that reduce the ecological impact of construction activities.
This study aims to address the critical issue of construction waste management by investigating the potential reuse of demolished concrete in combination with rice husk ash (RHA) to develop an innovative composite material. RHA, a byproduct derived from the combustion of rice husks, is a pozzolanic material rich in silica and widely used in cement and concrete production, ceramics, and as a filler in various industries. By integrating RHA into the composite, this research seeks to produce a high-performance construction material that not only alleviates the environmental impact of construction waste but also aligns with the principles of a circular economy.
The circular economy framework, which emphasizes resource efficiency, waste reduction, and material reuse, has gained recognition as a viable solution to the environmental issues associated with conventional linear economic models. In the construction sector, adopting circular economy principles entails reconsidering the entire life cycle of building materials—from production to disposal—to minimize waste generation and maximize resource efficiency. This research supports these principles by investigating how recycled materials, particularly demolished concrete, can be reintegrated into new construction applications, thereby reducing reliance on virgin raw materials.
The primary objective of this study is to assess the feasibility of utilizing a composite material composed of demolished concrete and RHA as an environmentally sustainable alternative to traditional construction materials. Through comprehensive experimental analysis, the research will evaluate the composite's mechanical, thermal, and environmental properties. Mechanical characteristics, including compressive strength, tensile strength, and durability, will be examined to determine its suitability for construction purposes. Additionally, thermal properties such as insulation performance and thermal conductivity will be analyzed to assess the material's potential for energy-efficient building designs. The environmental impact of the composite will also be studied, with a focus on carbon footprint reduction, resource optimization, and waste minimization.
A crucial aspect of this research is the investigation of the combined effects of demolished concrete and RHA. The hypothesis suggests that incorporating RHA will not only enhance the mechanical properties of the composite but also contribute to sustainability by reducing dependence on conventional cement, which is associated with high carbon emissions. By substituting a portion of cement with RHA, this study aims to create a material that offers both performance enhancements and environmental benefits. Additionally, utilizing recycled aggregates from demolished concrete is expected to improve the composite's sustainability by decreasing the demand for natural aggregates, thus conserving natural resources and mitigating the environmental impact of aggregate extraction.

Keywords: Compressive strength, demolished aggregate, rice husk ash (RHA), flexural strength, natural aggregate.

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I. INTRODUCTION

The construction industry worldwide is shifting towards more sustainable and environmentally responsible practices to minimize ecological damage and manage resource scarcity. One of the key innovations in this field is the incorporation of rice husk ash (RHA) into cement concrete. This method not only helps in reducing the environmental impact of construction but also transforms waste materials into useful components, contributing to the development of strong and long-lasting structures.

1. Contextualizing Sustainable Construction:

The increasing demand for construction materials has resulted in the overuse of natural resources and a surge in construction and demolition (C&D) waste. Sustainable construction focuses on meeting infrastructure demands while reducing environmental harm. Utilizing demolished waste and rice husk ash (RHA) in cement concrete supports waste minimization efforts and aligns with circular economy principles.

2. Demolished Waste as a Resource:

Construction debris, including concrete rubble, is often disposed of in landfills, leading to environmental pollution. Treating this waste as a reusable resource offers a sustainable solution by integrating it into concrete production. This approach not only reduces landfill waste but also decreases reliance on natural aggregates, lowering the environmental impact of extraction and processing.

3. Rice husk ash (RHA):

Rice husk ash (RHA), a byproduct generated from the combustion of rice husks, is a highly pozzolanic material due to its rich silica content. Its fine particle size and reactive nature make it suitable for various industrial applications, including its use as a supplementary cementitious material in concrete, enhancing strength and durability. Additionally, RHA finds applications in ceramics, insulation materials, and as a filler in plastic and rubber industries. Utilizing RHA in construction not only improves material performance but also promotes sustainable waste management by repurposing agricultural byproducts.

4. Environmental and Performance Benefits:

Incorporating demolished waste and RHA into cement concrete provides several advantages, both environmentally and structurally. This approach helps lower carbon emissions, preserves natural resources, enhances the material's durability, and improves resistance to challenging environmental conditions. Additionally, it contributes to reducing the overall environmental footprint of construction activities, making the process more sustainable.

5. Challenges and Research Frontiers:

Although the benefits are evident, challenges like standardization, quality assurance, and industry acceptance remain significant barriers. Continuous research is essential to overcome these issues, enhance material performance, and develop innovative solutions. This will facilitate the broader implementation of demolished waste and RHA-based cement concrete in the construction sector.

II. OBJECTIVE

This research aims to provide comprehensive insights into the technical, environmental, economic, and societal benefits of incorporating demolished waste and RHA-based cement concrete in construction, contributing to sustainable development in the built environment. The specific objectives include:

- Assessing the reduction in carbon emissions achieved by replacing conventional cement with RHA in concrete mixtures.
- Evaluating the environmental advantages of repurposing demolished waste, thereby reducing landfill accumulation.
- Investigating the mechanical properties and durability of RHA-based concrete, focusing on strength, permeability, and resistance to harsh conditions.
- Examining the effects of using demolished waste on the structural integrity and overall performance of concrete elements.
- Analyzing material cost savings and the long-term economic benefits associated with adopting these sustainable construction materials.

DIFFERENT RESEARCH WORK

(1) This study explores the replacement of natural coarse aggregates with recycled concrete aggregates and the partial substitution of cement with 15% rice husk ash (RHA) to enhance concrete sustainability. Aggregates from demolished bridge structures in Dhaka and RHA from brick kilns were used. A mix ratio of 1:1.5:3 (cement: sand: aggregates) was maintained with a 0.45 water-cement ratio. Strength tests on 32 concrete cubes at 14 and 28 days showed that modified concrete exhibited 4.66% higher

compressive strength and 7.9% greater tensile strength than conventional concrete. The pozzolanic reaction of RHA contributed to improved durability, making it a promising material for sustainable construction. (Md. Shah Newaz Aftab Chayon et al.,2024)

(2) This study explores sustainable alternatives to conventional concrete materials by incorporating PLA, rice husk (RH), and demolished waste (DW) in Grade 30 concrete. A mix ratio of 1:1.5:3 with a 0.55 water-cement ratio was used. Nine different concrete mixtures were developed, replacing PLA (2%-6%), RH (50%-100%), and DW (20%) while maintaining a control sample. A total of 54 cubes were tested for compressive strength, water absorption, and density at 7 and 28 days. The results showed that increased PLA, RH, and DW content reduced mechanical strength, with RH increasing permeability due to void formation. Despite weaker interfacial transition zones (ITZs) in DW aggregates, they showed potential as an alternative coarse aggregate. The study suggests optimizing mix designs with advanced techniques like optimized triple mixing (OTM) and carbon fiber reinforcement (CFRP) to improve concrete performance while reducing environmental impact. (Sarathchandra M.G.A.S. et al.,2020)

(3) This study investigates the feasibility of enhancing sustainability in construction by replacing conventional materials in Ordinary Portland Cement (OPC) concrete. Ground Granulated Blast Furnace Slag (GGBS) is explored as a substitute for cement, while Demolishing Waste (DW) replaces coarse aggregate. The research assesses varying percentages of GGBS replacement (0%, 10%, 20%, 30%, 40%, 50%, 60%) with a constant 30% DW replacement. Mechanical and durability properties are evaluated to determine the impact on concrete performance. The findings indicate improved workability, mechanical strengths up to 40% GGBS replacement, and enhanced durability in alkaline environments. The study emphasizes the potential of GGBS and DW to contribute to sustainable construction practices. (GANIKAPUDI AKHIL. et al.,2023)

(4) This study explores the incorporation of recycled fine aggregate (RFA) into geopolymer mortars as a sustainable solution. By replacing natural aggregates with varying RFA percentages, the research investigates effects on fresh properties, mechanical characteristics, and drying shrinkage. Key findings reveal that preprocessed RFA, especially above 75%, significantly enhances flowability and compressive strength. (Shilun Liu et al.,2023)

(5) The paper discusses differences in properties between reclaimed concrete aggregate (RCA) and natural aggregate, reviewing improvement techniques. Physical modification involves mechanical and thermodynamic methods, while chemical modification employs acid treatment, water glass strengthening, carbonation, inorganic slurry strengthening, and polymer strengthening. Microbial modification utilizes specific microorganisms for carbon deposition. (Yingqiang Su et al.,2023)

(6) India's construction sector is modernizing, leading to increased repair and demolition activities. With natural resources like stone and sand depleting, recycling construction and demolition (C&D) waste is essential. This study focuses on using recycled concrete aggregates (RCA) to replace natural coarse aggregates, enhancing waste management and sustainability. Concrete samples with RCA were tested for workability, compressive strength, and durability at 7 and 28 days. Results showed that while RCA affects workability, it offers a viable alternative. Proper C&D waste management, following the six R’s (Reduce, Reuse, Recycle, Recover, Redesign, Remanufacture), can support sustainability and future urban growth. (Jayasmita Mahakud et al.,2021)

(7) This study explores using fly ash (FA) and rice husk ash (RHA) in geopolymer-stabilized recycled concrete aggregate (RCA) for lightweight pavement bases. FA from power plants and RHA from rice mills were combined with sodium hydroxide (NaOH) and sodium silicate (Na_2SiO_3) as an alkaline activator. UCS tests at 7, 28, and 60 days showed strength increased with lower RHA/FA and $NaOH/Na_2SiO_3$ ratios. A 60/40 RHA/FA mix with a unit weight of 21.1 kN/m³ is suitable for low and high-traffic roads, confirming FA-RHA-geopolymer RCA as a sustainable road base material. Theerapruet Poltue et al.,2019)

(8) This study examines the impact of using 100% recycled coarse aggregates (RCA) and 0–35% rice husk ash (RHA) as a cement replacement in concrete. Various properties, including workability, strength, density, and durability, were analyzed over 7, 28, and 90 days. The results show that increasing RHA reduces workability and early strength but improves later-age pozzolanic activity. A 10–15% RHA replacement with RCA maintains acceptable strength and workability, making it suitable for construction. Higher RHA levels (>20%) significantly reduce mechanical properties. This research supports using RCA and RHA for sustainable concrete applications. (Rupali Subhasmita Padhi et al.,2018)

(9) This study explores using recycled concrete aggregates (RCA) and 10% rice husk ash (RHA) as a partial cement replacement in concrete. A total of 135 specimens were tested for workability,

compressive strength, and tensile strength at different curing ages. The results show that RCA reduces workability and early strength, but adding 10% RHA improves compressive strength over time. However, RCA significantly lowers tensile strength, making it unsuitable for high-tensile applications. The study recommends using RCA with 10% RHA for sustainable construction and suggests further research to enhance tensile strength through optimized aggregate size and mix proportions. (Naraindas Bheel et al.,2018)

(10) This study investigates the stabilization of clay soil using pond ash (PA), rice husk ash (RHA), and cement. Various tests, including Proctor compaction, California bearing ratio (CBR), SEM, and XRD, were conducted to assess soil properties. Results showed that increasing PA and RHA reduces maximum dry density while increasing optimum moisture content. RHA exhibited stronger pozzolanic behavior, enhancing soil strength. The best stabilization mix was found to be 4% cement, 10% RHA, and 40% PA. These findings suggest that locally available materials can improve soil stability for embankments and subgrade applications. (Deepak Guptaet al.,2016)

(11) This study evaluates the use of quarry dust as a partial sand replacement in high-strength concrete (HSC) containing rice husk ash (RHA). Concrete mixes of 60 MPa and 70 MPa were tested with quarry dust replacing sand at 10–40%. Results showed that 20% quarry dust provided the optimal mix, with minor reductions in strength and workability compensated by proper mix design and superplasticizers. The study confirms that quarry dust, combined with RHA, can be a sustainable alternative to sand for producing HSC with desirable mechanical properties. (S.N. Raman et al.,2011)

III. CONCLUSION

Building on previous studies, the use of demolished waste combined with rice husk ash (RHA) in cement concrete presents a viable solution for sustainable construction. Given the construction sector's heavy reliance on raw materials and its contribution to waste generation, exploring alternative materials is essential. Incorporating recycled aggregates from demolished concrete helps reduce dependence on natural resources while minimizing landfill waste.

This research demonstrates the practicality of using demolished waste and RHA in cement concrete, supporting sustainable construction practices. Applying these findings can enable the industry to lower its environmental impact, conserve resources, and advance circular economy principles by repurposing waste. Ultimately, this approach aligns with global sustainability goals, promoting a more responsible and eco-friendly construction sector.

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