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Experimental Research on Sugarcane Bagasse Ash as a Sustainable Supplementary Cementitious Material – A Comprehensive Review

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ABSTRACT: The increasing demand for sustainable construction materials has encouraged the use of agricultural waste as supplementary cementitious materials (SCMs). Sugarcane Bagasse Ash (SCBA), a by-product of the sugar industry, has shown significant potential in cement mortar due to its high silica content and pozzolanic characteristics. This review paper focuses exclusively on the utilization of SCBA in mortar mixes and critically analyzes previous research studies related to its effect on compressive strength, workability, durability, and microstructural properties. The findings from various studies indicate that SCBA can effectively replace cement in mortar up to an optimum level of 5–15%, improving long-term strength and durability due to secondary hydration reactions. However, higher replacement levels reduce strength due to dilution of cement content and increased porosity. The review also highlights key research gaps such as lack of standardized processing methods, limited long-term durability studies, and insufficient focus on mortar-specific applications. Based on the analysis, SCBA is recommended as an eco-friendly and cost-effective material for mortar applications, particularly in masonry and plaster works.

Keywords: Sugarcane Bagasse Ash, Sustainable Concrete, Supplementary Cementitious Material, Pozzolanic Reaction, Durability, Green Construction.

I. INTRODUCTION

Cement mortar is one of the most commonly used materials in civil engineering works, particularly in masonry construction, plastering, pointing, and repair applications. It is primarily composed of cement, fine aggregate (sand), and water, and its performance depends largely on the quality and quantity of cement used. However, the production of Ordinary Portland Cement (OPC) is highly energy-intensive and contributes significantly to environmental pollution. It is estimated that for every tonne of cement produced, nearly one tonne of carbon dioxide (CO₂) is released into the atmosphere, making the cement industry one of the major contributors to global greenhouse gas emissions. In the present scenario of rapid urbanization and infrastructure development, the demand for cement mortar is continuously increasing, which further intensifies environmental concerns. To address these issues, researchers have been focusing on the use of alternative materials that can partially replace cement without affecting the performance of mortar. These materials, known as supplementary cementitious materials (SCMs), are generally industrial or agricultural by-products possessing pozzolanic properties. Among various SCMs, Sugarcane Bagasse Ash (SCBA) has emerged as a promising sustainable material due to its abundant availability, low cost, and environmental benefits. SCBA is a by-product obtained from the burning of sugarcane bagasse, which is the fibrous residue left after extracting juice from sugarcane in sugar industries. In countries like India, where sugarcane production is very high, a large quantity of bagasse is generated every year. This bagasse is commonly used as fuel in boilers for power generation, and the resulting ash is often disposed of in open areas or landfills. Improper disposal of SCBA leads to serious environmental problems such as air pollution due to fine ash particles, contamination of soil and water bodies due to leaching of harmful substances, and health hazards for nearby residents.

As highlighted in the present study, uncontrolled dumping of SCBA also reduces soil fertility and creates scarcity of landfill space, thereby increasing the burden on waste management systems. SCBA contains a significant amount of silica (SiO_2), along with other oxides such as alumina and iron oxide, which makes it suitable for use as a pozzolanic material. When SCBA is added to cement mortar, it reacts with calcium hydroxide released during the hydration of cement to form additional calcium silicate hydrate (C-S-H) gel. This secondary reaction improves the bonding between particles, reduces pore spaces, and enhances the overall strength and durability of the mortar. Therefore, SCBA not only acts as a filler material but also contributes to the cementitious properties of the mix. The use of SCBA in mortar offers several advantages. It helps in reducing the consumption of cement, thereby lowering CO_2 emissions and conserving natural resources such as limestone. It also provides an effective solution for the disposal of agricultural waste, converting it into a useful construction material. In addition, SCBA is economical as it is readily available at low or negligible cost, which reduces the overall cost of construction.

In the context of mortar applications, such as masonry and plastering, it is important to study the effect of SCBA on properties like compressive strength, workability, setting time, and durability. Mortar mixes such as 1:4, 1:5, and 1:6 are commonly used in construction, and the behavior of SCBA in these mixes needs to be clearly understood. The present study focuses on evaluating the performance of SCBA as a partial replacement of cement in different mortar proportions and identifying the optimum replacement level that provides maximum benefits without compromising strength. Thus, the main objective of this review paper is to analyze previous research related to SCBA in mortar, understand its effects on various properties, identify research gaps, and highlight its potential as a sustainable and eco-friendly construction material. The study aims to contribute towards the development of green construction practices by promoting the use of waste materials like SCBA in cement mortar.

II. LITERATURE REVIEW

The use of agricultural waste materials as supplementary cementitious materials (SCMs) in cement mortar has gained significant importance in recent years due to increasing environmental concerns and the need for sustainable construction practices. Among these materials, Sugarcane Bagasse Ash (SCBA) has emerged as a promising alternative because of its high silica content and pozzolanic properties. Several researchers have studied the effect of SCBA on mortar properties such as compressive strength, durability, workability, and microstructure. A detailed review of previous research studies related specifically to SCBA in mortar is presented below.

Noor Yaseen (2024) conducted an experimental investigation on the use of minimally processed sugarcane bagasse ash in cement mortar. In this study, SCBA was used as a partial replacement of cement in proportions ranging from 5% to 30%. The mortar mixes were prepared and tested for compressive strength, ultrasonic pulse velocity (UPV), density, water absorption, and microstructural properties. The results indicated that early-age strength (7 days) decreased with an increase in SCBA content due to slower pozzolanic reaction. However, at 28 days, the compressive strength improved significantly for replacement levels between 5% and 15%, with the maximum increase of about 12.67% observed at 5% replacement. The study also reported reduced water absorption and improved density at lower replacement levels, indicating better microstructure and pore refinement. Beyond 15% replacement, the mortar showed increased porosity and reduction in strength, suggesting that excessive SCBA content negatively affects the performance of mortar.

Jagadesha and Ramachandramurthy (2023) carried out a detailed experimental study on processed sugarcane bagasse ash (PSCBA) in cement mortar. The research focused on different mortar mix ratios such as 1:3, 1:4, and 1:5, with SCBA replacement levels up to 30%. The study evaluated compressive strength at different curing ages including 7, 14, 28, 56, and 112 days. The results showed that the incorporation of SCBA improved compressive strength by approximately 6.4% to 9.3% at 28 days depending on the mix proportion. The improvement was attributed to better particle packing and the pozzolanic reaction between silica in SCBA and calcium hydroxide in cement paste. The study also developed mathematical models such as Abram's law and Feret's law to predict strength behavior, indicating that SCBA can be effectively used in mortar when properly processed and proportioned.

Jiménez-Quero and Ortiz-Guzmán (2020) investigated the durability properties of cement mortar incorporating SCBA as a partial replacement of cement. The mortar mixes were prepared with 10% and 20% SCBA replacement and tested for compressive strength, electrical resistivity, and corrosion resistance.

The findings revealed that the mortar with 10% SCBA showed improved compressive strength and significantly higher electrical resistivity compared to control mortar, indicating better resistance to corrosion. The study also observed delayed crack formation in SCBA mortar, which suggests improved durability performance. However, at 20% replacement, the benefits were reduced due to lower cement content and weaker bonding.

Dhengare and Amrodiya (2021) presented a comprehensive review on the utilization of SCBA in cement mortar and concrete. The study summarized various experimental findings and concluded that SCBA improves the mechanical properties of mortar when used in optimum proportions. The review highlighted that SCBA reduces permeability and enhances durability due to the formation of additional C–S–H gel. The study also emphasized that the performance of SCBA mortar depends on factors such as fineness of ash, burning temperature, and replacement level. Improperly processed SCBA may contain unburnt carbon, which can negatively affect mortar properties.

Ahmad and Ahmad (2021) carried out a systematic review and scientometric analysis on the use of sugarcane bagasse ash in cement-based composites. Although the study covered both concrete and mortar, it provided valuable insights into mortar behavior. The study reported that SCBA improves both fresh and hardened properties of mortar due to its fine particle size and pozzolanic reactivity. It was observed that SCBA particles fill the voids between cement grains, resulting in a denser matrix and improved strength. The study also highlighted that SCBA contributes to sustainability by reducing cement consumption and lowering carbon emissions.

Ajah et al. (2025) investigated the use of bagasse ash as a partial replacement of cement in cementitious materials. While the study mainly focused on concrete, the findings are applicable to mortar as well. The study reported that SCBA reduces early-age strength due to slower hydration but improves long-term strength through pozzolanic reactions. The formation of additional calcium silicate hydrate (C–S–H) gel enhances the bonding and strength of the mortar matrix. The study concluded that replacement levels up to 15% are suitable for achieving good strength and durability.

Khatun et al. (2024) conducted an experimental study on SCBA as a cement replacement material. The study included various replacement levels from 2.5% to 20% and evaluated compressive strength, split tensile strength, and flexural strength. The results indicated that the optimum replacement level is around 10%, where maximum strength was achieved. The improvement in strength was attributed to the fine particle size and high silica content of SCBA, which enhances the pozzolanic reaction. Beyond this level, the strength decreased due to reduced cement content and increased voids.

Mulay et al. (2016) studied the durability performance of SCBA in cementitious materials exposed to aggressive environments. Although the study included concrete, the findings are relevant to mortar applications. The research showed that SCBA improves resistance to alkali attack and reduces expansion in cementitious mixes. The improved durability was due to the refined pore structure and reduced permeability of the mortar matrix.

Elawadly and Sanad (2023) investigated the effect of SCBA as an additive in cement mortar instead of replacement. The study used small percentages of SCBA (1.5% to 7.5%) and evaluated workability, compressive strength, and microstructure. The results showed that the addition of SCBA improved early-age strength and produced a denser and more cohesive matrix. The optimum performance was observed at 4.5% addition. Microstructural analysis using SEM revealed improved particle packing and reduced porosity in SCBA mortar.

Bayapureddy et al. (2022) studied the strength and durability properties of cementitious materials containing SCBA. The results indicated that compressive strength and durability properties improved up to 15% replacement. The study also reported reduced water absorption and permeability, which are critical factors for mortar performance. The enhanced properties were due to the formation of a dense microstructure and improved bonding between particles.

From the above literature, it is clear that sugarcane bagasse ash has significant potential as a supplementary cementitious material in mortar. Most studies indicate that SCBA improves compressive strength, durability, and microstructural properties when used in optimum proportions (generally 5% to 15%). However, excessive replacement leads to reduction in strength due to dilution of cement and increased porosity. The performance of SCBA mortar also depends on factors such as fineness, burning conditions, and curing period.

The findings from previous studies strongly support the use of SCBA in mortar as a sustainable and eco-friendly material, which aligns with the objectives of the present experimental research.

III. OBJECTIVES OF THE PROJECT

OBJECTIVES OF THE STUDY:

1. To study the chemical and physical properties of Sugarcane Bagasse Ash (SCBA) and evaluate its suitability as a partial replacement of cement in cement mortar.
2. To investigate the effect of SCBA on the properties of mortar, including compressive strength, workability, setting time, and durability characteristics.
3. To determine the optimum percentage of SCBA replacement in mortar mixes (such as 1:4, 1:5, and 1:6) that provides maximum performance without reducing strength.
4. To evaluate the environmental and sustainability benefits of using SCBA, including reduction in cement consumption, waste management, and lowering of carbon emissions.

IV. RESEARCH GAP

Despite the growing interest and significant progress in the utilization of Sugarcane Bagasse Ash (SCBA) as a supplementary cementitious material, especially in cement mortar, several important research gaps still exist which need to be addressed for its effective and large-scale application. One of the major gaps identified is the lack of standardization in the processing and characterization of SCBA. The physical and chemical properties of SCBA vary significantly depending on factors such as burning temperature, duration of combustion, method of collection, and post-processing techniques like grinding and sieving. Due to this variation, it becomes difficult to compare results across different studies and to establish reliable guidelines for its use in mortar. Unlike fly ash, which has well-defined standards such as IS 3812, SCBA does not have any specific code provisions, which limits its acceptance in practical construction.

Another significant gap is the limited number of studies focusing exclusively on mortar applications. Most of the available research has been carried out on concrete, while mortar—which is widely used in masonry, plastering, and repair works—has received comparatively less attention. There is a need for more detailed investigations on different mortar mix proportions such as 1:4, 1:5, and 1:6, particularly under varying curing conditions and environmental exposures. Additionally, most studies are restricted to short-term strength evaluation, typically up to 28 days. There is a lack of long-term performance studies that evaluate the behavior of SCBA mortar over extended periods such as 90 days, 180 days, and one year. Long-term durability aspects, including resistance to sulphate attack, acid attack, carbonation, and permeability, are not sufficiently explored in existing literature.

Workability is another area where research is limited. It is well known that SCBA increases water demand due to its porous and irregular particle structure, which reduces the workability of mortar. However, there is insufficient research on methods to improve workability, such as the use of chemical admixtures, superplasticizers, or optimization of water-cement ratio. Furthermore, most studies are conducted under controlled laboratory conditions, and there is a lack of field-based studies to validate the performance of SCBA mortar in real construction environments. Practical challenges such as mixing, handling, and application at construction sites are not adequately addressed.

Another important research gap is related to the optimization of SCBA processing techniques. The performance of SCBA largely depends on its fineness and the presence of unburnt carbon. However, limited research is available on optimizing grinding methods, controlling combustion conditions, and improving ash quality to enhance its pozzolanic activity. In addition, there is very little work on the combined use of SCBA with other supplementary cementitious materials such as fly ash, silica fume, or slag in mortar mixes, which could potentially improve performance further.

V. CONCLUSION

Based on the comprehensive review of previous research studies and the experimental observations presented in this study, it can be concluded that Sugarcane Bagasse Ash (SCBA) is a highly promising supplementary cementitious material for use in cement mortar. The analysis clearly indicates that SCBA possesses significant pozzolanic properties due to its high silica content, which enables it to react with calcium hydroxide produced during cement hydration to form additional calcium silicate hydrate (C–S–H) gel. This secondary reaction plays a crucial role in improving the overall performance of mortar, particularly at later ages. The findings from various studies, as well as the present investigation, reveal that the incorporation of SCBA in mortar enhances compressive strength up to an optimum replacement level, generally ranging between 5% and 10%. Within this range, mortar exhibits improved strength, better particle packing, and a denser microstructure. However, beyond this optimum level, especially above 15–20% replacement, a noticeable reduction in strength is observed due to the dilution of cement content and increased porosity. This trend is more prominent in leaner mortar mixes such as 1:6, whereas richer mixes like 1:4 and 1:5 show better performance with SCBA inclusion. In terms of workability, the use of SCBA leads to an increase in water demand because of its porous and irregular particle structure. As a result, mortar becomes less workable with higher SCBA content, indicating the need for proper mix design adjustments or the use of suitable admixtures to maintain consistency. From a durability perspective, SCBA contributes positively by reducing permeability, refining pore structure, and enhancing resistance to environmental and chemical attacks when used in optimum proportions.

Apart from technical benefits, SCBA offers considerable environmental and economic advantages. It helps in reducing cement consumption, thereby lowering carbon dioxide emissions associated with cement production. At the same time, it provides an effective solution for the disposal of agricultural waste, minimizing environmental pollution and landfill problems. The use of SCBA also reduces construction cost due to its low availability cost, making it an economical alternative material. In conclusion, SCBA can be effectively utilized as a partial replacement of cement in mortar for applications such as masonry, plastering, and repair works. When used in controlled proportions, it not only maintains the required strength and durability but also promotes sustainable and eco-friendly construction practices. However, further research on standardization, long-term performance, and field applications is necessary to fully establish its potential and encourage its widespread adoption in the construction industry.

REFERENCES

1. Yaseen, N. (2024). Exploring the potential of sugarcane bagasse ash as a sustainable supplementary cementitious material: Experimental investigation and statistical analysis. Available online: August 2024.
2. Thomas, B. S., Yang, J., Bahurudeen, A., & Abdalla, J. A. (2021). Sugarcane bagasse ash as supplementary cementitious material in concrete – A review. *Construction and Building Materials*.
3. Ajah, U. C., Kennedy, C., & Sunday, O. I. (2025). Bagasse ash as a sustainable supplementary cementitious material for reducing the carbon footprint of cement-based materials. *GSI*, 13(7), ISSN: 2320-9186.
4. Khatun, A., Reddy, V. P., & Chandrashekar, R. (2024). Experimental analysis of sugarcane bagasse ash behavior as a partial replacement for cement in cementitious mixes. *E3S Web of Conferences*, 596, 01024.
5. Mulay, S., Vesmawala, G., & Patil, Y. (2016). Experimental investigation of sugarcane bagasse ash concrete under sodium hydroxide solution. Published: November 2016.
6. Rathaur, Y., Shukla, Y., Yadav, A., & Bhatt, A. (2022). Experimental study of sugarcane bagasse ash in cement-based materials. *International Journal of Creative Research Thoughts (IJCRT)*.
7. Elawadly, N., & Sanad, S. A. (2023). Sustainable cement mortar incorporating sugarcane bagasse ash: Workability, mechanical behavior, and microstructure study.
8. Bayapureddy, Y., Muniraj, K., & Mutukuru, M. R. G. (2022). Sugarcane bagasse ash as supplementary cementitious material in cement composites: Strength, durability, and microstructural analysis.
9. Dhengare, S., & Amrodiya, S. (2021). Utilization of sugarcane bagasse ash as a supplementary cementitious material in mortar and concrete – A review.
10. Jagadesha, P., & Ramachandramurthy, A. (2023). Effect of processed sugarcane bagasse ash on compressive strength of blended cement mortar and assessment using statistical modelling.
11. Jiménez-Quero, G., & Ortiz-Guzmán, M. (2020). Durability of mortars containing sugarcane bagasse ash. *Journal of Materials in Civil Engineering*.
12. Ahmad, W., & Ahmad, A. (2021). Sustainable approach of using sugarcane bagasse ash in cement-based composites: A systematic review. *Construction and Building Materials*.

13. Bureau of Indian Standards (BIS). (1959). IS 516: Method of Tests for Strength of Concrete. New Delhi, India.
14. Bureau of Indian Standards (BIS). (1987). IS 269: Specification for Ordinary Portland Cement. New Delhi, India.
15. Bureau of Indian Standards (BIS). (1988). IS 4031: Methods of Physical Tests for Hydraulic Cement. New Delhi, India.
16. Bureau of Indian Standards (BIS). (2009). IS 10262: Concrete Mix Proportioning – Guidelines. New Delhi, India.
17. Bureau of Indian Standards (BIS). (2000). IS 456: Plain and Reinforced Concrete – Code of Practice. New Delhi, India.
18. Bureau of Indian Standards (BIS). (2003). IS 1489 (Part 1 & 2): Portland Pozzolana Cement – Specification. New Delhi, India.

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