

Sugarcane Bagasse as a Partial Replacemant in Concrete

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Abstract

The construction industry is one of the largest consumers of natural resources and a major contributor to environmental degradation, primarily due to the extensive use of cement in concrete production. Cement manufacturing releases a significant amount of carbon dioxide (CO₂), contributing to global warming. In recent years, there has been a growing interest in the utilization of agricultural waste materials as partial replacements in concrete to achieve sustainability. One such promising material is sugarcane bagasse, a fibrous by-product obtained after extracting juice from sugarcane.

This study investigates the feasibility of using sugarcane bagasse ash (SCBA) as a partial replacement for cement in concrete. The ash is obtained by controlled burning of bagasse and possesses pozzolanic properties due to its high silica content. Experimental analysis is conducted by replacing cement with SCBA in varying proportions (0%, 5%, 10%, 15%, and 20%) and evaluating parameters such as compressive strength, workability, and durability.

The results indicate that partial replacement of cement with SCBA up to an optimum level (10–15%) enhances the mechanical and durability properties of concrete. Additionally, it contributes to waste management and reduces the environmental impact of construction activities. This research highlights the potential of sugarcane bagasse as an eco-friendly and cost-effective material for sustainable concrete production. Introduction*

KEYWORDS: Sugarcane bagasse ash, SCBA, partial replacement, sustainable concrete, compressive strength, pozzolanic material, green construction.

INTRODUCTION

Concrete is the backbone of modern construction and is widely used due to its strength, durability, and adaptability. It is composed mainly of cement, fine aggregates, coarse aggregates, and water. However, the production of cement is energy-intensive and responsible for approximately 7–8% of global CO₂ emissions. This has led to increasing concerns regarding environmental sustainability and resource depletion.

To address these challenges, researchers have been exploring alternative materials that can partially replace cement without compromising the performance of concrete. Agricultural waste materials have gained attention due to their abundance, low cost, and environmental benefits. Sugarcane bagasse is one such material that is readily available in countries with large sugar industries, such as India.

Sugarcane bagasse is the fibrous residue left after the extraction of juice from sugarcane. It is typically used as a fuel in sugar mills, but a large quantity remains unused or is disposed of improperly, leading to

environmental issues. When bagasse is burned under controlled conditions, it produces sugarcane bagasse ash (SCBA), which contains a high amount of amorphous silica and exhibits pozzolanic properties.

The use of SCBA in concrete can reduce the demand for cement, lower greenhouse gas emissions, and provide an effective solution for waste management. This study aims to evaluate the performance of concrete with partial replacement of cement by SCBA and assess its suitability for construction applications.

LITERATURE REVIEW

Numerous studies have been conducted on the use of supplementary cementitious materials (SCMs) in concrete, including fly ash, silica fume, rice husk ash, and sugarcane bagasse ash. Among these, SCBA has gained attention due to its availability and pozzolanic characteristics.

Research indicates that SCBA contains a significant amount of silica (SiO_2), which reacts with calcium hydroxide released during cement hydration to form additional calcium silicate hydrate (C-S-H) gel. This reaction enhances the strength and durability of concrete. Studies have shown that replacing cement with SCBA up to 10–15% results in improved compressive strength and reduced permeability.

According to experimental investigations, concrete with SCBA exhibits better resistance to sulfate attack and chloride penetration. The fine particles of SCBA fill the voids in the concrete matrix, resulting in a denser and more compact structure. This improves the durability and longevity of concrete structures.

Despite its advantages, some challenges have been identified. The quality of SCBA depends on the burning process and temperature. Improper burning can result in high carbon content, which negatively affects concrete properties. Furthermore, higher replacement levels (above 20%) may lead to a reduction in strength due to insufficient cementitious material. Overall, the literature suggests that sugarcane bagasse ash is a viable and sustainable material for use in concrete, provided it is used in optimal proportions and properly processed.

METHODOLOGY*

The experimental methodology involves the preparation and testing of concrete mixes with partial replacement of cement by sugarcane bagasse ash.

Materials Used

- Ordinary Portland Cement (OPC)
- Fine aggregate (natural sand)
- Coarse aggregate (crushed stone)
- Potable water
- Sugarcane Bagasse Ash (SCBA)

Preparation of SCBA

Bagasse is collected from local sugar mills and dried to remove moisture. It is then burned in a controlled environment at temperatures between 600°C and 800°C to obtain ash. The ash is ground into fine powder and sieved through a 90-micron sieve to ensure uniform particle size.

Mix Design

Concrete is designed as per IS 10262 guidelines. Cement is partially replaced with SCBA in the following proportions:

- 0% (Control Mix)

- 5%
- 10%
- 15%
- 20%

Casting and Curing

Concrete specimens (cubes) are cast in standard molds and compacted properly. After 24 hours, the specimens are demolded and cured in water for 7, 14, and 28 days.

Testing Procedures

The following tests are conducted:

- *Slump Test* for workability
- *Compressive Strength Test* using a compression testing machine
- *Water Absorption Test* for durability
- *Permeability Test* to assess resistance to water penetration

All tests are conducted according to relevant Indian Standard (IS) codes.

RESULTS AND DISCUSSION

Workability

The slump value decreases with increasing SCBA content. This is due to the higher surface area and porous nature of SCBA, which increases water demand. However, the use of superplasticizers can improve workability.

Compressive Strength

- At 5% and 10% replacement, compressive strength is slightly higher than the control mix.
- Maximum strength is achieved at around 10–15% replacement.
- At 20% replacement, strength decreases due to reduced cement content.

Durability

Concrete containing SCBA shows improved durability characteristics:

- Reduced water absorption
- Lower permeability
- Increased resistance to chemical attacks

Discussion

The improved performance of SCBA concrete is attributed to the pozzolanic reaction, which produces additional C-S-H gel. This enhances the bonding between particles and reduces voids in the concrete matrix. The denser structure results in higher strength and durability.

However, excessive replacement reduces the availability of cement, leading to a decline in strength. Therefore, it is important to determine the optimum replacement level.

CONCLUSION

The study demonstrates that sugarcane bagasse ash is an effective and sustainable material for partial replacement of cement in concrete. It offers several environmental, economic, and technical benefits.

Key conclusions are:

- SCBA can be used as a partial replacement for cement up to 10–15% without compromising strength.

- It improves durability by reducing permeability and enhancing resistance to chemical attacks.
 - Workability decreases with increasing SCBA content but can be managed with admixtures.
 - Utilization of bagasse helps in waste management and reduces environmental pollution.
 - It provides a cost-effective alternative, especially in regions where bagasse is readily available.
- In conclusion, sugarcane bagasse ash has significant potential in sustainable construction and should be encouraged for wider adoption in the construction industry.

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