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# Partial Replacement of Cement Using Sugarcane Baggassse Ash to Enhance the Strength of Concrete

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**Abstract:** *We are aware that a lot of damage is done to environment in the manufacture of cement. It involves lot of carbon emission associated with other chemicals. The researches have shown that every one ton of cement manufacture releases half ton of carbon dioxide, so there is an immediate need to control the usage of cement. On the hand materials wastes such as Sugar Cane Bagasse Ash is difficult to dispose which in return is environmental Hazard. The Bagasse ash imparts high early strength to concrete and also reduce the permeability of concrete. The Silica present in the Bagasse ash reacts with components of cement during hydration and imparts additional properties such as chloride resistance, corrosion resistance etc. Therefore, the use of Bagasse ash in concrete not only reduces the environmental pollution but also enhances the properties of concrete and also reduces the cost. It makes the concrete more durable This project mainly deals with the replacement of cement with Bagasse ash in fixed proportions on SCBA blended concrete. The concrete mix designed by varying the 2 proportions of Bagasse ash for 10%, 15%, 20%, the cubes are been casted and cured in normal water for ages of 7, 14 and 28 days. The test result indicates that the strength of concrete increase up to 10% Sugar cane bagasse ash replacement of cement.*

**Keywords:** *Bagasse ash*

## I. INTRODUCTION

The construction industry plays a vital role in the economic development of any country. However, it is also one of the largest consumers of natural resources and a significant contributor to environmental degradation. The demand for conventional construction materials such as cement, sand, and aggregates has increased rapidly due to urbanization, industrialization, and population growth. Among these materials, cement is the most widely used binding material in concrete production. Despite its extensive use, the manufacturing of cement is highly energy-intensive and results in the emission of large quantities of carbon dioxide ($CO_2$), a major greenhouse gas responsible for global warming and climate change. In recent years, there has been a growing concern about the environmental impact associated with cement production and the depletion of natural resources. This has led researchers and engineers to explore alternative materials that can partially replace cement without compromising the strength and durability of concrete. One of the most promising approaches is the utilization of industrial and agricultural waste materials as supplementary cementitious materials. These materials not only help in reducing the environmental burden but also promote sustainable development in the construction sector.

**Materials**

- Cement (OPC)
- Bagasse Ash


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- Fine Aggregate
- Coarse Aggregate
- Water Mould

## II. METHODOLOGY

The use of bagasse ash, a by-product of the sugar industry, in concrete block production presents an eco-friendly and sustainable alternative to conventional materials. This project focuses on partially replacing cement with bagasse ash to improve waste utilization and reduce environmental impact. Initially, bagasse ash is collected, dried, and sieved to obtain uniform particle size. Concrete mixes are then prepared with varying percentages of bagasse ash as a cement substitute. Standard moulds are used to cast concrete blocks, which are then cured for specified periods. The blocks are tested for compressive strength, water absorption, and durability. Finally, results are compared with conventional concrete blocks to evaluate performance and feasibility. OPC 53 Grade cement conforming to IS 12269:2013 was used as the sole binder in the Normal mixes. The 53 Grade designation indicates a minimum 28-day compressive strength of 53 MPa when tested as standard mortar cubes per IS 4031. Key physical and chemical properties verified prior to use are presented in Table 3.1. The specific gravity of 3.15 and fineness (Blaine surface area $\geqslant$ 225 $m^2/kg$) are consistent with standard OPC 53 Grade requirements. The initial setting time of 30 minutes minimum and final setting time of 600 minutes maximum were confirmed in compliance with IS 12269:2013

| Material | Mass (kg) | Volume (m3) |
|---|---|---|
| Cement (OPC) | 358.18 | 0.249 |
| Fine Aggregate | 740.68 | 0.463 |
| Coarse Aggregate | 1037.69 | 0.716 |
| Water | 197 | 0.197 |

Table 01 – Normal Concrete Mix Proportion per m3

| Materials | Quantity(kg) | | |
|---|---|---|---|
| | 10%SCBA | 15%SCBA | 20%SCBA |
| Cement | 322.36 | 304.45 | 286.54 |
| Baggasse ash | 35.82 | 53.73 | 71.64 |
| Water | 197(lit) | 197(lit) | 197(lit) |
| Fine Agg | 740.68 | 740.68 | 740.68 |
| Coarse Agg | 1037.69 | 1037.69 | 1037.69 |

Table 02 – Concrete Cement Replace SCBA Mix Proportion

## III. RESULTS AND DISCUSSION

**Compressive Strength Test**

The results obtained from the experimental study on concrete blocks incorporating sugarcane bagasse ash (SCBA) as a partial replacement of cement are presented and discussed in this section. The main objective of this study is to evaluate the influence of SCBA on the mechanical and durability properties of concrete blocks. Various tests such as compressive strength, water absorption, and density were conducted on both control and SCBA-modified concrete mixes. The performance of SCBA concrete blocks is compared with conventional concrete to identify the optimum replacement level. The discussion highlights the effect of SCBA's pozzolanic nature on improving the microstructure of concrete. It is observed that SCBA contributes to better particle packing and reduced pore spaces within the concrete matrix. However, excessive replacement of cement with SCBA may lead to a reduction in early-age strength. The results also indicate improvements in durability characteristics due to reduced permeability. The behavior of concrete blocks is analyzed with respect to different curing ages. Overall, this section explains how SCBA influences the overall performance of concrete blocks and supports The Normal OPC mix was designed for M20 characteristic compressive

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strength (fck = 20 MPa) in accordance with IS 10262:2019. The target mean compressive strength (f'ck) is calculated as 26.6 MPa. In this study, 10% of cement is replaced with bagasse ash by mass, while maintaining the total binder content constant. The modified binder consists of 90% OPC and 10% bagasse ash. The water–binder ratio is kept unchanged to achieve the target mean strength. This experimental study focuses on the partial replacement of Ordinary Portland Cement (OPC) with Sugarcane Bagasse Ash (SCBA) to evaluate its impact on the mechanical properties of normal strength concrete. Based on an initial M20 grade design (as per IS 10262:2019), the following methodology and material proportions were established for the casting of test specimens. The fundamental design maintains a total binder content of 358.18 kg/m³ with a strictly controlled water-to-binder (w/b) ratio of 0.55. In this specific experimental variation, 10% of cement is replaced with Bagasse Ash, resulting in a reduced cement content of 322.36 kg/m³, while 35.82 kg/m³ of Bagasse Ash is introduced as a supplementary cementitious material. By maintaining the water content at 197 kg/m³, the chemical balance for hydration and pozzolanic reaction is preserved. The skeletal structure of the mix is supported by 740.68kg/m³ of fine aggregate and 1037 kg/m³ of coarse aggregate. The results demonstrate that variation in material composition leads to measurable changes in properties, and comparison with the control mix provides a clear understanding of these variations.

**Compressive Strength (Cement 90% + Bagasse ash 10%)**

| Days | Cube 1 Load (Mpa) | Cube 2 Load (Mpa) | Cube 3 Load (Mpa) | Strenth(Mpa) |
|---|---|---|---|---|
| 7 | 14.8 | 15.2 | 15.3 | 15.10 |
| 14 | 17.9 | 18.3 | 18.5 | 18.25 |
| 28 | 19.2 | 19.6 | 20.0 | 19.60 |

Table 03 – Compressive strength 7,14. And 28 days 10% bagasse ash

The compressive strength of concrete with 10% bagasse ash shows a consistent increase with curing time, starting at 15.10 MPa at 7 days, rising to 18.25 MPa at 14 days, and reaching 19.60 MPa at 28 days. This indicates that the addition of bagasse ash contributes positively to strength development, likely due to its pozzolanic reaction enhancing the concrete matrix over time. The gradual strength gain reflects effective hydration and improved bonding, while the minimal variation among the three cubes suggests good uniformity in mixing and casting. Overall, the results show satisfactory performance and slightly improved strength compared to conventional concrete.

**Compressive Strength (Cement 85% + Bagasse ash 15%)**

| Days | Cube 1 Load (Mpa) | Cube 2 Load (Mpa) | Cube 3 Load (Mpa) | Strentth (Mpa) |
|---|---|---|---|---|
| 7 | 14..0 | 14.2 | 14.4 | 14.20 |
| 14 | 17.2 | 17.5 | 17.8 | 17.50 |
| 28 | 18.2 | 18.6 | 18.9 | 18.57 |

Table 04 – Compressive strength 7,14. And 28 days 15% bagasse ash

The compressive strength of the concrete shows a steady increase with curing time, rising from an average of 14.20MPa at 7 days to 17.50 MPa at 14 days and reaching 18.57MPa at 28 days.

This gradual improvement indicates proper hydration of cement and good curing conditions, leading to stronger bonding within the concrete matrix. The relatively small variation among the three cube results at each age suggests uniform mixing, casting, and testing. Overall, the results demonstrate normal strength development and satisfactory performance of the concrete mix.

**Compressive Strength (Cement 80% + Bagasse ash 20%)**

| Days | Cube 1 Load (Mpa) | Cube 2 Load (Mpa) | Cube 3 Load (Mpa) | Strenth(Mpa) |
|---|---|---|---|---|
| 7 | 11.8 | 12.1 | 12.6 | 12.15 |
| 14 | 15.4 | 15.8 | 16.1 | 15.78 |
| 28 | 16.8 | 17.1 | 17.4 | 17.10 |

Table 05 – Compressive strength 7,14. And 28 days 20% bagasse ash

The compressive strength of concrete with 20% bagasse ash increases with curing time, from 12.15 MPa at 7 days to 15.78 MPa at 14 days and 17.10 MPa at 28 days. Although strength development follows the normal trend, the values are lower compared to mixes with lower or no bagasse ash content, indicating that higher replacement may reduce early and ultimate strength. This is likely due to slower pozzolanic activity and reduced cement content at higher replacement levels. However, the consistent gain in strength and low variation among cubes suggest proper mixing and curing, with overall acceptable but comparatively reduced performance.

**Flexural strength test**

| Days | 10% SCBA | 15%SCBA | 20%SCBA |
|---|---|---|---|
| 7 | 3.10 | 2.85 | 2.50 |
| 14 | 3.75 | 3.40 | 3.00 |
| 28 | 4.25 | 3.90 | 3.45 |

Flexural strength increased with curing age. The 10% SCBA mix showed the highest value of 4.25 at 28 days.

**Split Tensile Test**

| Days | 10% SCBA | 15%SCBA | 20%SCBA |
|---|---|---|---|
| 7 | 1.80 | 1.62 | 1.40 |
| 14 | 2.25 | 2.05 | 1.82 |
| 28 | 2.72 | 2.40 | 2.10 |

The Split Tensile strength followed a similar pattern as compressive strength. The 10% replacement achieved maximum strength.

**Rebound Hammer Test**

| Mix | Rebound Number | Quality |
|---|---|---|
| 10% SCBA | 31 | Good |
| 15% SCBA | 28 | Fair |
| 20% SCBA | 24 | Fair |

The Rebound Hammer values indicate good surface hardness for 10% SCBA concrete

**RCPT Test**

| Mix | Charge Passed | Permeability |
|---|---|---|
| 10% SCBA | 1450 | Low |
| 15% SCBA | 1750 | Moderate |
| 20% SCBA | 2150 | Moderate |

The 10% SCBA mix showed lower chloride penetration indicating better durability,

**Durability Test (Water Absorption)**

| Mix | Water Absorption(%) |
|---|---|
| 10% SCBA | 3.20 |
| 15% SCBA | 3.85 |
| 20% SCBA | 445 |

Water absorption increased as SCBA percentage increased, showing higher porosity at higher replacement level.

## IV. CONCLUSION

At 10% SCBA replacement, compressive strength was nearly equal to conventional concrete. The 28-day strength reached about 19.20 MPa, showing minimal impact on performance This indicates SCBA's effective pozzolanic action and improved microstructure. With 15% SCBA, a slight reduction in strength was observed. Although strength gain followed a normal trend, 28-day strength was marginally lower At 20% SCBA replacement, a significant strength reduction occurred at all ages The concrete failed to achieve the required M20 strength at 28 days. Overall, 10% SCBA is the optimum replacement level for maintaining strength. SCBA enhances sustainability and durability when used in proper proportions. The results show that normal concrete achieves the highest compressive strength, while increasing replacement levels (5%,10%, 15%, 20%) consistently reduce strength. Even at 10% replacement, the strength reduction is minimal, but beyond 15% the drop becomes more significant. At 20%, the strength falls noticeably below the target for M20 concrete (20 MPa). Therefore, partial replacement up to about 10–15% can be considered acceptable, but higher percentages adversely affect compressive strength and are not recommended for structural applications. maintaining measurable performance within the tested parameters.

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