

An Empirical Study on Substituting Sugarcane Bagasse Ash for a Portion of Cement in Mortar

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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 has 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. 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 mortar and also reduce the permeability of mortar. 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 mortar and also reduces the cost. It makes the mortar more durable. This project mainly deals with the replacement of cement with Bagasse ash in fixed proportions and analysing the effect of SCBA blended mortar. The concrete mix designed by varying the proportions of Bagasse ash for 0%, 5%, 10%, 15%, 20%, 25%, 30% the cubes are been casted and cured in normal water for ages of 7, 14 and 28 days. The test result indicate that the strength of mortar increase up to 10% Sugar cane bagasse ash replacement with cement.

Index Terms- Sugarcane bagasse ash, waste disposal management, durability, eco- friendly.

I. INTRODUCTION

Ordinary Portland cement is recognized as a major construction material throughout the world. Researchers all over the world today are focusing on ways of utilizing either industrial or agricultural waste, as a source of raw materials for industry. The control of the environmental pollution, land waste to the controlled, on reusing matter many studies were carried out on the utilization of sugarcane bagasse ash most of the studies are focused on the improvement of physical and chemical properties of sugarcane bagasse ash in mortar.

The successful utilization of these raw materials will result in the reduction of global warming and environmental loading, waste management cost and mortar production cost, besides enhancing the properties of mortar in both fresh and hardened state. Cement production alone accounts for nearly 8% of global CO₂ emissions. Finding sustainable alternatives for cement is crucial for mitigating the environmental impact of construction. Sugarcane bagasse ash, a by-product of sugar production, emerges as a promising candidate for partial cement replacement in mortar. This study aims to empirically investigate the feasibility and benefits of utilizing Sugarcane bagasse ash in mortar through a comprehensive evaluation of its mechanical, durability, and economic performance.

Currently, there has been an attempt to utilize the large amount of bagasse ash, the residue from an in-line sugar industry and the bagasse biomass fuel in electric generation industry. When this waste is burned under controlled conditions, it also gives ash having amorphous silica, which has pozzolanic properties. Therefore, it is possible to use Sugarcane Bagasse Ash as cement replacement material to improve quality and reduce the cost of construction materials such as mortar, mortar pavers, mortar roof tiles and soil cement interlocking block. The present study was carried out by Partial Replacement of Cement by SCBA of sugarcane bagasse.

Sugarcane Bagaase

In tropical and subtropical nations, sugarcane is the principal burning of sugarcane bagasse yields sugarcane bagasse ash. Due to their immediate dumping on open lands and the formation of waste heaps there, the SCBA causes environmental nuisance

It causes problems with the environment and economy. Sugarcane bagasse ash is an agro-industrial waste material composed mainly of the silicon di oxide, Which has been extensively used in Portland cement blended mortars and concretes. Sugarcane bagasse as shown in figure 1



Sugarcane bagasse ash as shown in figure 1, is the fibrous residue left behind after sugarcane stalks are crushed to extract their juice for sugar production. It is a dry, pulpy material that is traditionally considered a waste product, but it has several potential uses.

Rounded and smaller aggregate particles provide better flowability and deformability of concrete and also prevents segregation.

1. Need For Study

Cement production contributes significantly to CO₂ emissions. Exploring alternatives like bagasse ash can reduce the environmental impact of the construction industry.

Sugarcane bagasse ash is a major agricultural waste posing disposal challenges. Utilizing it in mortar offers a sustainable waste management solution.

Rising cement costs strain construction budgets. Investigating bagasse ash as a cost-effective substitute can make mortar more affordable.

Advantages Of Using Sugarcane Bagasse Ash In Mortar

Reduced CO₂ emissions: Cement production is a major contributor to greenhouse gases. Using bagasse ash, a waste product, can significantly decrease CO₂ footprint of mortar.

Sustainable waste management: Finding productive uses for bagasse ash reduces landfill burden and promotes circular economy principles.

Objectives

- The present study aims at mix design of M20 grade of mortar and to find required constituents of it.
- To study the effect of addition of Sugarcane Bagasse Ash (0%, 5%, 10% and 15%) on compressive strength of mortar (M20)

Characteristics of Scba in Mortar

- **Pozzolanic Activity:** SCBA exhibits pozzolanic properties, reacting with calcium hydroxide in the presence of water to form additional calcium silicate hydrates (CSH), contributing to the strength and durability of mortar.
- **Fineness:** The particle size distribution of SCBA affects its reactivity and contribution to mortar properties. Finer particles generally react more rapidly and contribute to denser microstructure and improved strength.
- **Chemical Composition:** SCBA typically contains silica (SiO₂), alumina (Al₂O₃), and other oxides. The chemical composition influences its reactivity, setting characteristics, and potential interactions with other components in the mortar mix.
- **Water Demand:** SCBA may influence the water demand of mortar mixes due to its surface characteristics and reactivity. Adjustments in water content or the use of water-reducing admixtures may be necessary to maintain workability
- **Setting Time:** The addition of SCBA may affect the setting time of mortar due to its pozzolanic action.

II. LITERATURE REVIEW

- Sagar Dhengar et.al., (2015) has studies about the developing countries, accumulation of unmanaged agricultural waste has resulted in an increased environmental concern. Recycling of such agricultural wastes is the viable solution not only to pollution problem, but also the problem of land filling.
- Anil pratapsingh(2015) They studied on “ Effect of use of Bagasse Ash on Strength of Concrete”, with increasing demand and consumption of cement, researchers and scientist are in search of developing alternate binders that are eco friendly and contributes towards waste management.
- Nithin Kumar Reddy et.al.,(2016) author deals with the replacement of cement with bagasse ash in fixed proportions and the analysis of the effect of magnesium sulfate on SCBA mixed concrete.
- Zhang.J et.al.,(2016) investigated the effect of SCBA (10% & 15%) on the durability of concrete against sulphate attack, chloride penetration, and freezingthaw cycles. Both replacement levels offered increased resistance compared to the cont

III. METHODOLOGY

A methodology is a broad approach to data collection, whereas the methods are the exact tools used for data extraction. Therefore, Figure 3.1 represents the detailed explanation of procedure.

Mix Design

- The M20 mortar mix ratio is a mix proportion of 1:1.5:3 (cement : sand : coarse aggregates). This ratio means 1 part of cement, 1.5 parts of sand and 3 parts of aggregates.
- The M20 mortar mix ratio is designed to produce a minimum compressive strength of 20 N/mm² at 28 days as per IS:456

Material Collection

Cement

- A cement is a binder, a chemical substance used for construction that sets, hardens, and adheres to other materials to bind them together.

Sugarcane Bagasse Ash

- Sugar Cane Bagasse is the fibrous residue of juice removed in sugarcane milling and is one major biomass byproduct fuel, composed of trash, tops, and leaves of sugarcane plant.
- Due to their immediate dumping on open lands and the formation of waste heaps there, the SCBA causes environmental nuisances.
- Mix design is a selection of raw materials in optimum proportions to give concrete with required properties in fresh and hardened state and for some specialisation.



Figure 3.1 Processing of Sugarcane Bagasse Ash

Material Test

Construction Materials Testing (CMT) primarily involves testing structural materials used to build new projects from the ground up, materials and components used to construct new additions or new component

Specific Gravity Test

The specific gravity (Gs) of a material is the ratio of the mass of a unit volume of soil solids at a specific temperature to be mass of an equal volume of gas-free distilled water at the same temperature. The specific gravity of soil is usually reported at 20oC.

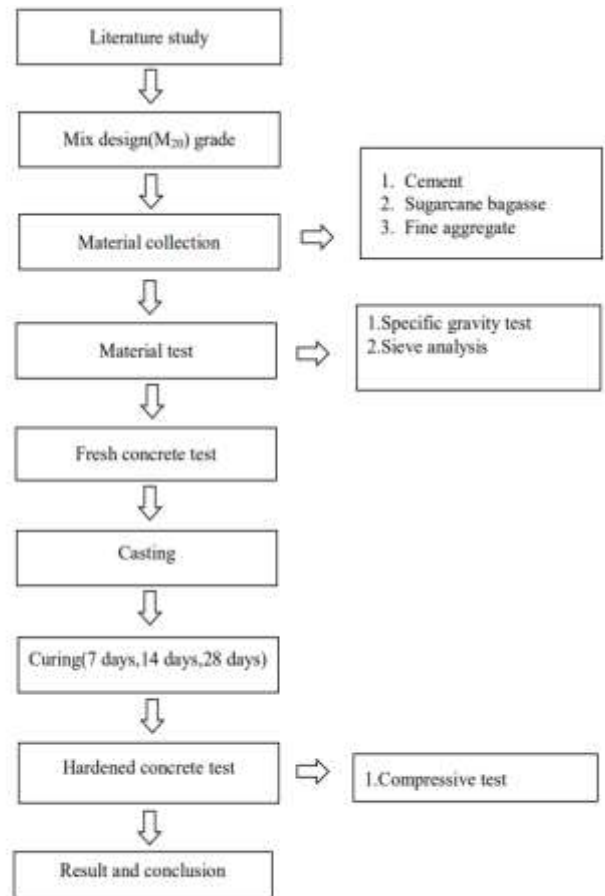


Figure 3.2 Methodology

Fresh Concrete Test

Fresh concrete tests measure factors such as strength, consistency, unit weight, air content, and temperature. By performing such tests consistently, you can detect changes in concrete that may affect its long-term performance.

Casting

Casting materials are usually metals or various time setting materials that cure after mixing two or more components together; examples are epoxy, concrete, plaster an

Curing

Curing plays an important role on strength development and durability of concrete.

Curing takes place immediately after concrete placing and finishing, 22 and involves maintenance of desired moisture and temperature conditions, both at depth and near the surface, for extended periods of time.

Compressive Test

Compressive strength refers to the strength of hardened concrete when measured by a compression test, which entails crushing cylindrical concrete in a compression testing machine.

Testing Of Material

General

This chapter deals with the properties test which include specific gravity test and sieve analysis test of fine aggregate.

Testing of Materials

- Specific gravity test
- Abrasion test
- Sieve analysis
- Water absorption test
- Consistency test

Determination Of Specific Gravity Of Fine Aggregate

Definition The specific gravity of any sample is defined as the ratio of the mass of a given volume of that sample to the mass of an equal volume of water at that given temperature.

Apparatus required

- Pycnometer
- Balance
- Weight box
- Desiccators
- Distilled water
- Vacuum source
- Thermomete

Table 4.1 Specific gravity of fine aggregate

S.NO	DESCRIPTION	NOTATION	READINGS
1	Weight of pycnometer	W1	638g
2	Weight of pycnometer + oven dried sand	W2	1530g
3	Weight of pycnometer + oven dried sand + water	W3	2056g
4	Weight of pycnometer + full of water	W4	1510g

FORMULA USED FOR SPECIFIC GRAVITY:

$$\begin{aligned} \text{Specific gravity} &= \frac{(W2-W1)}{(W2-W1) - (W3-W4)} \\ &= \frac{(1530 - 638)}{(1530 - 638) - (2056 - 1510)} \\ &= 2.6 \end{aligned}$$

Determination of Specific Gravity Of Cement

Definition

Cement's specific gravity is defined as the mass-to-density ratio of cement relative to some other standard material. However, regardless of mass or density, the volume in each condition should be the same.

Apparatus required

- Pycnometer
- Weight box
- Desiccators
- Distilled water

Table 4.2 Specific gravity of Cement

S.NO	DESCRIPTION	NOTATION	READINGS
1	Weight of pycnometer	W1	638g
2	Weight of pycnometer + cement	W2	830g
3	Weight of pycnometer + oven dried cement	W3	1590g
4	Weight of pycnometer + full of kerosene	W4	1454g

FORMULA USED FOR SPECIFIC GRAVITY:

$$\begin{aligned} \text{Specific gravity} &= \frac{(W2-W1)}{(W2-W1) - (W3-W4)} \\ &= \frac{(830 - 638)}{(830 - 638) - (1590 - 1454)} \\ &= 2.92 \end{aligned}$$

Mix Design

General

Cement mortar is the most used material in the construction area, and it comes in a paste state. It is a mixture of cement, fine aggregate and water.

Uses Of Cement Mortar

Cement mortar is a binding material, it is mainly used to bind construction materials like bricks, stones and concrete masonry

Design Stipulations

Materials required for 1m³ cement mortar, ratio CM 1:3
 CM 1:3 = cement mortar
 1:3 (cement : fine aggregate)

Cement:

Cement = [(part of cement) / (sum of ratio)] x total volume required]

Part of cement = 1
Sum of ratio = (1+3) = 4
The total volume required = wet volume x dry volume
Wet volume = actual required volume
Dry volume = 1.33 (for meter)
Total volume required = $1 \times 1.33 = (1/4) \times 1.33 = 0.3325\text{m}^3$
Unit weight of cement = 1440 kg/m³

Fine Aggregate

Fine aggregate = [(part of fine aggregate) / (sum of ratio)] x total volume required]

part of fine aggregate = 3

Part of cement = 1

Mix Proportions For

1m³ :

Cement = 478.08 kg

Water = 239 litre

Fine aggregate = 1596 kg

Water-cement ratio = 0.55.5



Figure 5.2 Cube Curing

Universal Testing Machine

A Universal Testing Machine (UTM) is a type of mechanical testing equipment that is utilized for determining the mechanical properties of various materials, such as tensile strength, compressive strength, bending strength, and shear strength.



Figure 5.1 Cube Casting



Figure 5.3 Universal Testing Machine

VI. RESULTS AND DISCUSSION

As a result, the compressive strength of mortar specimens containing various percentages of sugarcane bagasse ash (SCBA) as partial replacement for cement was measured.

It was observed that as the percentage of SCBA increased, the compressive strength initially decreased but then started to increase, reaching an optimal value at a certain replacement percentage.

Cube Casting and Curing

Prepare the mould: Clean and oil the mould to ensure easy removal of the hardened concrete cube.

Curing

Concrete sets and hardens as a result of a chemical reaction between cementitious materials and water.

Curing is the process of maintain satisfactory temperature and moisture conditions in concrete long enough for hydration to develop the desired concrete properties

Table 6.1 Compressive strength test result

SAMPLE	7 days N/mm ²	14 days N/mm ²	28 days N/mm ²
S 20	11.2	12	16
S 21	10.6	14.93	14.57
S 22	12.64	15.3	19.7
S 23	8.17	9.9	11.02
S 24	8	12.8	13.15
S 25	8.53	12.08	12.08
S 26	8	13.1	14.57

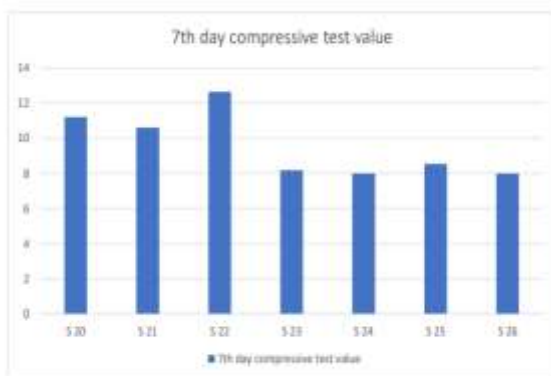


Figure 6.2 Bar chart of 7th day compressive test value

VII. CONCLUSION

- SCBA in mortar gives the higher compressive strength as compare to conventional mortar, hence optimum results

were found at the 10% replacement of cement with SCBA.

- Use of high volume SCBA as a replacement of cement, in any construction work provides lower impact on environment (reduced CO₂ emission) and economical use of resources (energy conservation, use of by-product etc).
- If concrete with SCBA is mixed with water instead of cement, less heat is produced. In addition, it lessens the heat of hydration, which lessens temperature cracks and shrinkage in the concrete.
- The energy used in the production of cement is reduced when SCBA is used in place of cement.
- It is observed that there is an increase in the compressive strength at 10 % of SCBA and after replacement of 20 %it gets decreased slightly .The increase in strength is due to high reactivity of SCBA with Cement .
- From the above experimental results, it is proved that SCBA can be used as an alternative material for cement, reducing cement consumption and reducing the cost of construction. Use of industrial waste products saves the environment and conserves natural resources, achieves economy .
- SCBA cement has a slower heat of hydration, reducing the possibility of thermal cracking.

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