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Exploring the Feasibility of Incorporating Sugarcane Bagasse Ash and Granite Waste as Fine Aggregates in Concrete: An Experimental Study

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Abstract
This research focused on optimizing the bagasse ash to cement mix ratio and evaluating the suitability of bagasse ash as a replacement for cement to mitigate environmental degradation caused by high cement demand. The bagasse ash was ground in small batches, reducing its particle size to match the fineness of Portland cement. Following this size reduction, a comprehensive silicate analysis was conducted to determine the major chemical composition of bagasse ash.
A trial mix was formulated for a target strength of 30MPa, using a water-to-cement ratio of 0.45 and a cement content of 397.8kg/m3. To refine the final mix, the water-to-cement ratio was adjusted from 0.40 and 0.45 to 0.5 while maintaining a constant cement content. This adjustment, increasing the water content from 179kg/m3 to 198.9kg/m3, aimed to achieve the desired slump.
Blended pastes were examined for consistency, setting time, and soundness at varying replacement levels of 5%, 10%, and 15% by weight of cement. A total of 27 concrete mixes, comprising bagasse ash and cement, were cast in triplicate to account for variations in key factors influencing concrete properties. Fresh concrete underwent a slump cone test, and hardened concrete was tested for compressive strength at 28 days.
Optimal values for the water-to-cementitious materials ratio and fine-to-total aggregate ratios were identified, resulting in higher compressive strength at lower cementitious materials content. This optimization led to significant cost savings in concrete production. However, as the proportion of bagasse ash to cement increased beyond 10%, a slight decrease in compressive strength was observed. Despite this, all bagasse ash to ordinary Portland cement mixtures met the specified criteria.
Keywords: *Sugarcane Bagasse Ash, Granite Waste, Fine Aggregate, Concrete.*

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I. INTRODUCTION

The construction industry, a vital component of global infrastructure development, has been faced with the ever-increasing demand for sustainable and eco-friendly building materials. Concrete, being one of the most widely used construction materials, plays a significant role in shaping the built environment. However, the production of conventional concrete relies heavily on the consumption of natural resources, contributing to environmental degradation and carbon emissions. In this context, the quest for innovative and sustainable alternatives to traditional concrete materials has become a pressing concern in the field of civil engineering.

The utilization of waste materials as partial replacements for conventional construction aggregates has emerged as a promising strategy to reduce the environmental footprint of concrete production. This research endeavors to explore the potential of sugarcane bagasse ash (SCBA) and granite waste as sustainable alternatives to fine aggregate in concrete.

Sugarcane bagasse ash, a byproduct of the sugarcane industry, is abundantly available in many regions around the world. Its disposal poses a significant environmental challenge, and thus, repurposing it as a construction material could offer a sustainable solution. On the other hand, granite waste, generated during the processing of natural granite stone, is another underutilized resource with the potential to enhance the sustainability of concrete production. By incorporating these waste materials into concrete, we aim to reduce the demand for natural sand and mitigate the negative impacts associated with its extraction, such as habitat disruption and ecosystem degradation.

Sugarcane Bagasse Ash (SCBA)

is a valuable waste byproduct derived from the sugarcane industry. It is obtained from the combustion of sugarcane bagasse, the fibrous residue left behind after extracting juice from sugarcane for sugar production. SCBA is characterized by its fine, powdery texture and high silica content, making it a promising material for various applications, particularly in construction. This agricultural waste material has gained attention for its potential to enhance the sustainability of industries and reduce environmental impact. SCBA has found uses in fields such as concrete production, where it can serve as a partial replacement for cement, contributing to both waste reduction and improved material performance. Moreover, its abundance in sugarcane-producing regions positions it as a readily available and cost-effective resource for sustainable material innovation and environmentally responsible practices.

Granite Waste Granite waste, also known as granite byproducts or granite sludge, refers to the leftover material generated during the cutting and processing of granite stone for various applications, primarily in the construction and countertop industries. This waste consists of granite dust, small stone fragments, and residual slurry from the cutting and polishing processes. Granite waste is typically considered a byproduct of granite mining and manufacturing, and it has garnered attention due to its potential for reuse and recycling. While granite is a highly durable and sought-after natural stone, the disposal of its waste poses environmental challenges. However, efforts are being made to repurpose granite waste in sustainable ways, such as using it as a component in concrete, for landscaping purposes, or as a source of raw material for other industries, thereby reducing its environmental impact and promoting resource efficiency.

II. OBJECTIVES OF THE WORK

1. Evaluate Strength Properties:

- Assess the influence of sugarcane Bagasse Ash (BAGW) and Granite Waste (GW) as fine aggregates on the compressive strength of concrete.
- Examine the relationship between compressive strength and the water-cement ratio for different curing durations.

2. Investigate Durability Performance:

- Analyze the impact of BAGW and GW on the durability of concrete.
- Study the changes in water absorption capacity, capillary rise, and volume of permeable voids with varying curing ages.

3. Assess Flexural Behavior:

- Explore the flexural behavior of reinforced BAGW concrete beams.
- Investigate crack propagation, load-carrying capacity, and overall structural performance under flexural loads.

These objectives collectively aimed to provide insights into the potential of BAGW and GW as sustainable additions to concrete mixtures, with a focus on improving strength, durability, and overall performance in construction projects.

III. METHODOLOGY

Several non-conventional materials are used as the aggregate in concrete making. In the present study, Sugarcane bagasse ash and Granite waste were used as the partial replacement of river sand fine aggregate in concrete. The materials used and their properties, concrete mix design, preparation of test specimens, and various testing methods have adopted to examine the behavior of the specimens are highlighted in this chapter. The experimental investigation has been done in four stages, they are

a) Characterization of material
b) Strength studies
c) Durability studies
d) Flexural behavioral studies:

Table No.1: Mix Proportion of Conventional Concrete

Mix	Cement		River sand		Coarse aggregate		Water liters/m^3
	kg/m^3	m^3/m^3	kg/m^3	m^3/m^3	kg/m^3	m^3/m^3	
C 1	535	0.170	620	0.238	1120	0.4	192
C 2	485	0.154	662	0.254	1120	0.4	192
C 3	435	0.138	703	0.270	1120	0.4	192

C 4	400	0.127	733	0.281	1120	0.4	192
C 5	371	0.118	756	0.290	1120	0.4	192
C 6	340	0.108	782	0.300	1120	0.4	192

IV. RESULTSAND DISCUSSION

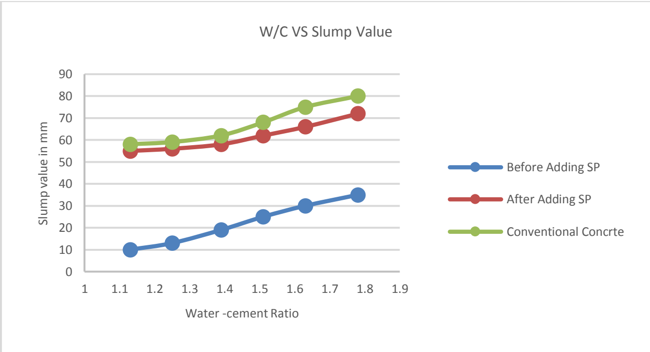

Figure 1: Relationship between Water-Cement Ratio and Slump for BAGW Fine Aggregate Concrete & Conventional Concrete

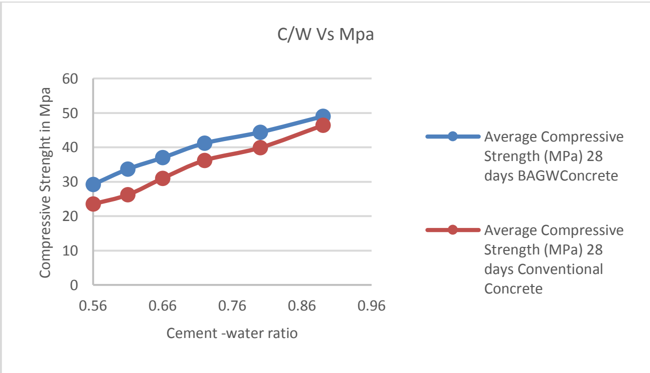

Figure 2 Relationship between Cement Water Ratio and 28 days Compressive Strength of BAGW Fine Aggregate Concrete & Conventional Concrete

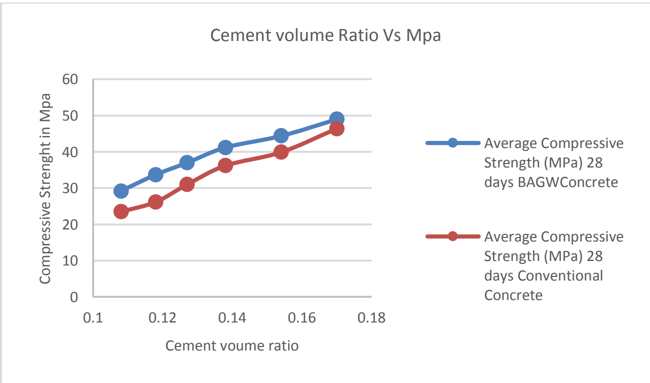

Figure 3. Relationship between the Volume of Cement and 28 days Compressive Strength of BAGW Fine Aggregate Concrete

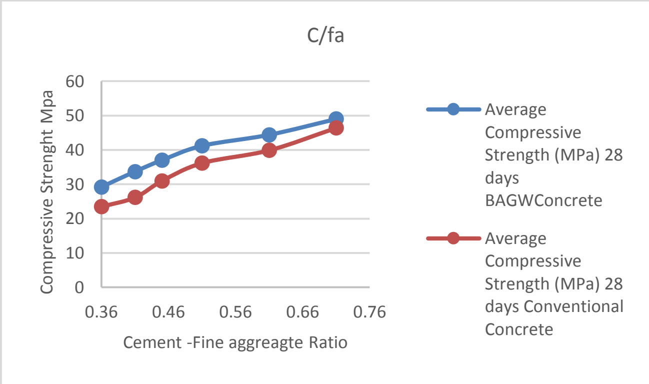

Figure 4. Relationship between the Volume of Cement/Volume of Fine Aggregate and 28 days Compressive Strength of BAGW Fine Aggregate Concrete

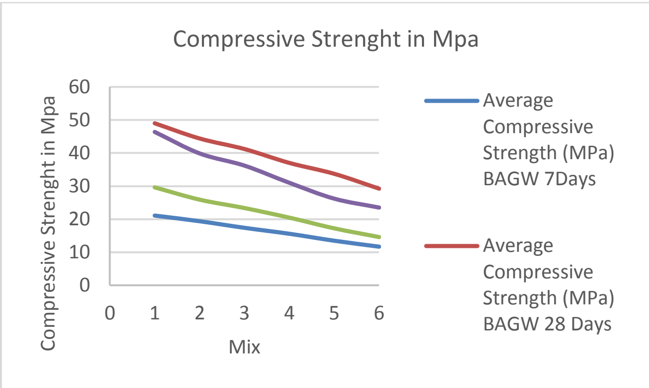

Figure 5 Pullout Test Result of BAGW and Conventional Concrete

V. CONCLUSION

In summary, this study investigated the effects of incorporating sugarcane Bagasse Ash (BAGW) and Granite Waste (GW) as fine aggregate replacements in concrete, assessing their impact on both strength and durability properties. The following key conclusions can be drawn:

1. Effect of Combined Sugarcane Bagasse Ash and Granite Waste Fine Aggregate on the Strength Characteristics of Concrete:

- The addition of Bagasse Ash (BAGW) and Granite Waste (GW) as fine aggregate replacements in concrete significantly enhances its strength properties.
- At 7 days, BAGW concrete exhibits slightly lower compressive strength compared to conventional concrete, but it surpasses conventional concrete at later ages.
- The relationship between compressive strength and water-cement ratio in BAGW concrete follows a similar trend to conventional concrete, allowing the application of basic water-cement ratio principles.

2. Effect of Combined Sugarcane Bagasse Ash and Granite Waste as Fine Aggregate on the Durability Performance:

- Water absorption capacity decreases with the age of concrete, indicating improved durability.
- BAGW concrete initially shows an increase in water absorption up to 28 days, but later, it gradually decreases.
- Capillary rise of water ceases after the third day of immersion, in line with BS 1881-Part 5 standards.
- The volume of permeable voids is reduced in BAGW concrete compared to conventional concrete, ranging from 10–15%, due to effective micro-pore filling.

3. Behavior of Reinforced Bagasse Ash and Granite Waste Fine Aggregate Concrete Beam in Flexure:

- Additional testing on reinforced BAGW concrete beams is required to assess their flexural behavior.
- Flexural performance, crack propagation, and load-carrying capacity of BAGW concrete beams should be investigated to determine their suitability for structural applications.

In conclusion, the incorporation of BAGW and GW in concrete holds promise for enhancing both the strength and durability of concrete structures, provided careful consideration of curing periods and long-term performance. These findings contribute to the ongoing efforts to develop sustainable and resilient construction materials.

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