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EXPIRIMENTAL INVESTIGATION ON PARTIAL REPLACEMENT OF CEMENT IN CONCRETE BY SUGARCANE BAGASSE ASH

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Abstract: Concrete is a ubiquitous construction material globally, with cement as a crucial component. Unfortunately, cement production is a major contributor to carbon dioxide emissions, exacerbating global warming. In response, researchers and engineers are actively seeking cement alternatives for concrete. One promising option is sugarcane bagasse ash, a by-product of the sugar industry abundant in countries like India. Bagasse ash is pozzolanic, capable of reacting with cement to form additional cementitious compounds, reducing the cement required in concrete. Beyond its environmental benefits, the use of bagasse ash can enhance concrete quality. It can boost strength and decrease permeability, resulting in more durable and corrosion-resistant concrete. To assess bagasse ash's impact on concrete properties, researchers can conduct experiments, varying the proportions of bagasse ash and cement in concrete mixes, and conducting tests to measure strength and durability over time. In summary, the incorporation of sugarcane bagasse ash as a partial cement substitute in concrete offers a dual advantage: mitigating the environmental impact of concrete production while improving material performance. Continued research and development in this field hold promise for more sustainable and long-lasting concrete solutions, advancing the construction industry towards greater environmental responsibility

1.Introduction

Concrete production is a major source of greenhouse gas emissions, with cement manufacturing alone responsible for a substantial 8% of global carbon dioxide emissions. To address this environmental concern, researchers are actively exploring alternative materials. One such material that has garnered significant attention in recent years is Sugarcane Bagasse Ash (SCBA).Sugarcane is a prominent crop in many regions, and its processing generates substantial quantities of bagasse, the fibrous residue left after juice extraction. The combustion of bagasse leaves behind bagasse ash as waste, which possesses pozzolanic properties suitable for potential use as a cement replacement material. Globally, sugarcane production exceeds 1500 million tons, with approximately 30% of sugarcane consisting of bagasse. After sugar extraction, about 8% of bagasse remains as waste ash, raising concerns about its disposal. Studies have demonstrated that SCBA can enhance certain properties of paste, mortar, and concrete, including compressive strength and water tightness, when used in specific replacement percentages and fineness.

The higher silica content in SCBA is believed to be the primary contributor to these improvements. Although the silicate content in SCBA may vary depending on burning conditions and raw material properties, it generally undergoes a pozzolanic reaction with cement hydration products, reducing the free lime in concrete. Bagasse, comprising hemicellulose, cellulose, lignin, wax, ash, and fibrous material, is generated as a significant by-product during sugarcane crushing. Typically, bagasse is incinerated for energy production, yielding substantial ash as a by-product. If not appropriately managed, this ash can pose environmental hazards. SCBA, with its pozzolanic properties, can react with calcium hydroxide in the presence of water, contributing to concrete's strength and durability. Numerous studies have explored the incorporation of SCBA as a partial cement substitute in concrete mixtures. For instance, replacing 10% of cement with SCBA led to a notable 4.4% reduction in carbon dioxide emissions, while a 20% replacement resulted in an even more significant 16.1% reduction. These findings underscore the potential of SCBA to significantly reduce the environmental footprint of concrete production. The exploration of materials like Sugarcane Bagasse Ash as cement replacements offers a promising avenue to mitigate the environmental impact of concrete production while enhancing its performance properties.

1.1. Sugarcane Bagasse Ash

Sugarcane Bagasse Ash (SCBA) is a valuable byproduct of the sugar industry, notably prevalent in regions with extensive sugarcane cultivation, such as India. It arises from the fibrous residue known as bagasse, which remains after sugarcane juice extraction. SCBA has garnered substantial attention in recent years for its potential as an eco-friendly and sustainable material, finding diverse applications.A key attribute of SCBA is its pozzolanic property, wherein it undergoes a chemical reaction with calcium hydroxide, commonly found in cement. This reaction leads to the formation of additional cementitious compounds, positioning SCBA as a viable candidate for partially substituting cement in concrete mixes. This utilization effectively reduces the overall carbon footprint associated with concrete production, a vital step towards environmental sustainability.

Numerous studies have substantiated SCBA's efficacy as a cement substitute. When integrated into concrete mixtures, it has exhibited the capacity to enhance several critical properties of the resulting material. These enhancements encompass heightened compressive strength, increased durability, reduced permeability, and augmented resistance to corrosion. Such improvements not only promote eco-friendliness but also render SCBA-infused concrete more robust and enduring. Moreover, the sustainable nature of SCBA is further accentuated by its source. Sugarcane, a globally significant agricultural crop, yields substantial quantities of bagasse during processing. The responsible disposal of bagasse ash as waste is a pertinent environmental concern. Therefore, the utilization of SCBA in concrete represents an environmentally conscious choice that repurposes this waste material, alleviating disposal challenges and reducing the reliance on traditional cement production, known for its energy intensity and significant carbon emissions.

1.2. Objective of the study

The objectives of this study are to determine the optimum percentage of sugarcane bagasse ash as a cement replacement in concrete while maintaining required strength and durability, assess its impact on workability and setting time, investigate effects on water absorption and permeability, evaluate long-term performance, and provide sustainable recommendations for its use in concrete production.

1.3. Applications of the project

The application of the project is to develop sustainable and environmentally friendly concrete by utilizing sugarcane bagasse ash as a partial replacement for cement. This eco-conscious concrete could find applications in various construction projects where strength, durability, and reduced environmental impact are key considerations, such as in building infrastructure, and other structural elements. Additionally, the research findings and recommendations could inform construction practices and contribute to more sustainable concrete production methods, aligning with global efforts to reduce carbon emissions and promote greener construction materials.

2. Methodology

The methodology consists of collecting materials, testing and selecting them, performing mix design with partial cement replacement using sugarcane bagasse ash, conducting workability tests, and casting concrete (M35) cubes and cylinders. These specimens are then subjected to compression and split-tensile tests to assess their strength properties.

2.1. Materials used

In concrete production, the essential components include cement, fine aggregate (e.g., sand), coarse aggregate (e.g., gravel), and water. Cement acts as the binder, while the aggregates provide structure, and water activates the cement. This project utilizes sugarcane bagasse ash (SCBA) as a partial cement replacement due to its pozzolanic properties, enhancing compressive strength, durability, and reducing permeability in the concrete mix.

2.2. Sugarcane Bagasse Ash

The incorporation of Sugarcane Bagasse Ash led to a noticeable increase in compressive strength after a curing period of 28 days. However, it's important to note that this improvement in compressive strength was supplemented by an enhancement in the permeability of the concrete. Furthermore, when the proportion of Sugarcane Bagasse Ash in the concrete is replaced by 10%, maximum compressive strength and split tensile strength were achieved.

Figure 1.Sugarcane Bagasse Ash

Properties of Titanium Dioxide

Chemical formula	=SiO2, representing silicon dioxide
Molar mass	=55 to 70 g/mol
Appearance	=Fine grey powder
Odor	=odorless
Density	=1.5 to 2.5g/cm^3
Specific gravity	=2.5

3. Mix Design

3.1. Parameters for Mix Design M35

Grade designation	: M35
Type of cement	: OPC 53 grade Conforming to IS 8112
Maximum nominal size of aggregate	: 20mm
Maximum cement content	: 320 kg/m^3
Maximum water cement ratio	: 0.43
Workability	: 100mm (slump)
Exposure condition	: Severe (for reinforced Concrete)
Degree of supervision	: Good
Type of aggregate	: Crashed granular aggregate
Maximum cement (OPC) content	: 450kg/m^3

3.2. Water Cement Ratio:

The W/C ratio mentioned inTable5of IS456 is 0.45W/C proposed is 0.43.

We should adopt The W/C ratio as 0.43.

Cement	=400Kg/m^3
Fine aggregate	=799Kg/m^3
Coarse aggregate	=1156.33Kg/m^3
Water	=172Kg/m^3

4. Preparation of Specimen

The cube casting mold is 15x15x15cm in size, and the cylinder mold is 152x305mm in size, according to IS: 10086-1982. When constructing the mold for use, the joints between the mold pieces must be thinly coated with oil, and a similar coating of oil must be put between the contact surfaces of the mold's bottom and the base plate to guarantee that no water escapes during filling. To avoid concrete adhesion, the inside surfaces of the assembled mold should be thinly coated with oil. There are four cubes and four cylinders cast.

The concrete casting process should be done at room temperature, such as 27^{o}C.The cement and sugarcane bagasse ash were thoroughly mixed by hand before being combined with fine and coarse aggregate. Following the mixing process, the desired water content is added to the mixture. The concrete mix should then be poured into the mold in three levels with a total of 25 tamping. After 24 hours, the mold should be removed and the curing process should begin for 14 days, and 28 days. The cubes and cylinders are removed after 14 days, and 28 days for strength testing.

Figure 2.Casted cubes and cylinders

5. Test Result for Hardened Concrete

The results obtained from the compressive strength test and split tensile strength of conventional concrete and sugarcane bagasse ash concrete is presented in this section.

5.1. Compressive Strength Test

Table 5.1.1.Compressive strength of concrete

SI No	% of cement replaced with SCBA	Compressive strength in N/mm2 at 14 days	Compressive strength in N/mm2 at 28 days
1	0%	37.67	40.6
2	5%	40	42.66
3	10%	44.4	47.55
4	15%	40.6	43.94
5	20%	36.9	39.13
6	25%	35.7	38.56

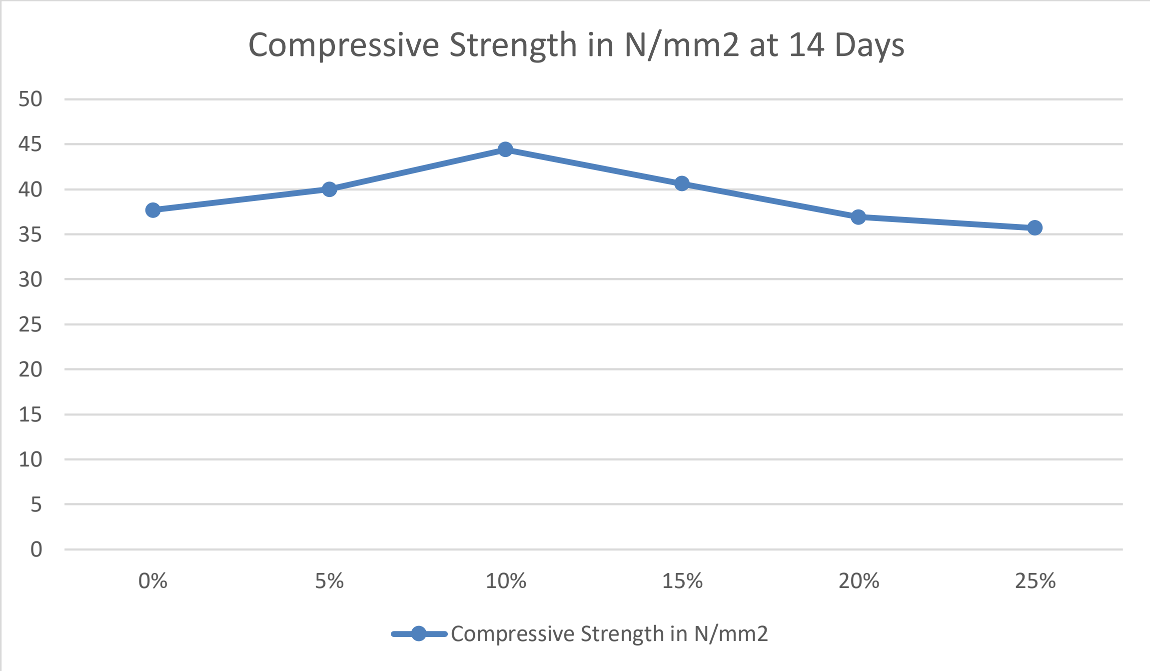

Figure 5.1.1.compressive strength testing of concrete

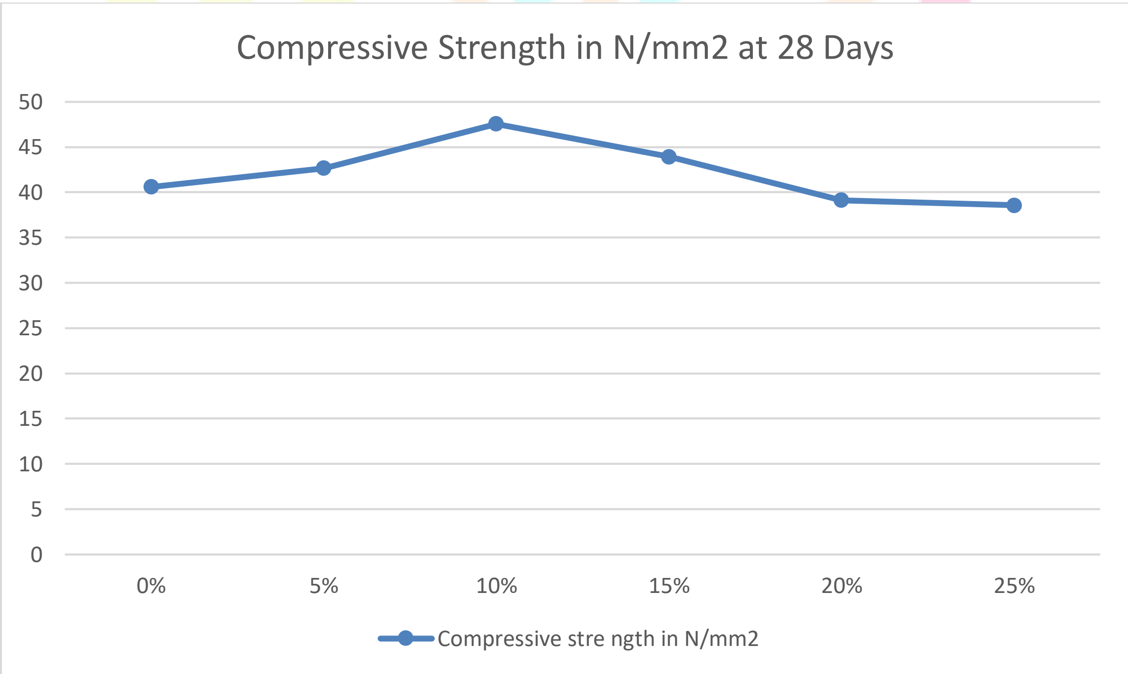

Figure 5.1.2.compressive strength testing of concrete

Figure 5.1.3.compressive strength testing of concrete

5.2. Split Tensile Strength

Table 5.2.1 Split Tensile Strength of Concrete

SI No	**% of cement replaced with SCBA**	**Split Tensile strength in N/mm2 at 14 days**	**Split Tensile strength in N/mm2 at 28 days**
1	0%	2.09	2.8
2	5%	2.78	3.42
3	10%	3.067	3.77
4	15%	2.89	3.5
5	20%	2.58	2.9
6	25%	1.89	2.52

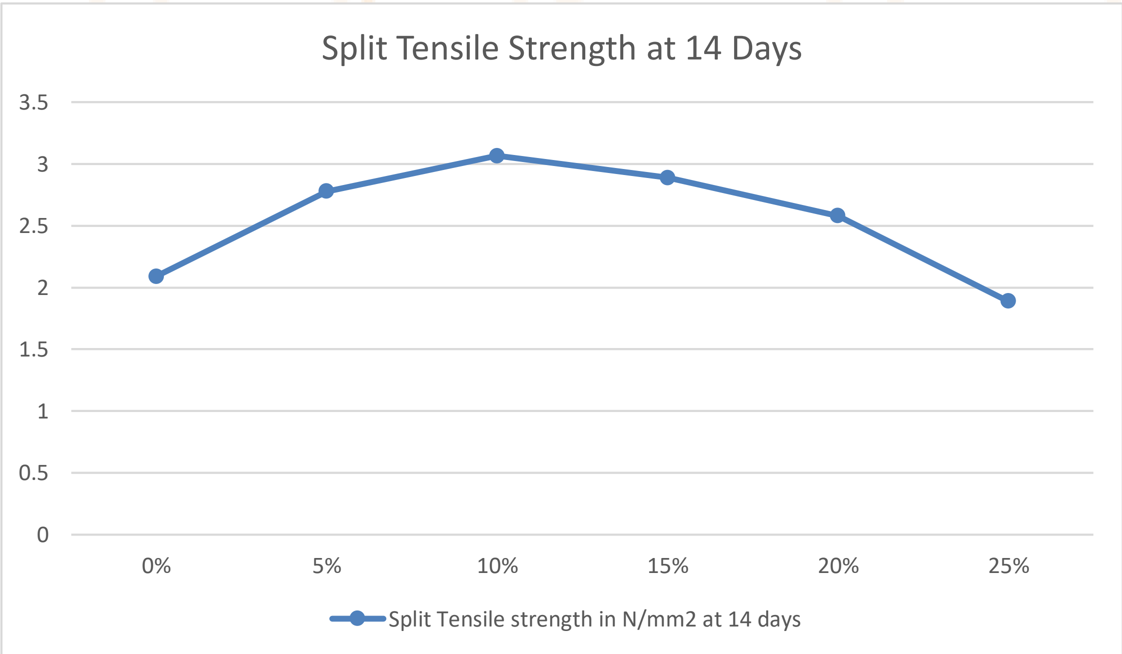

Figure 5.2.1.Split Tensile strength of concrete at 14 days

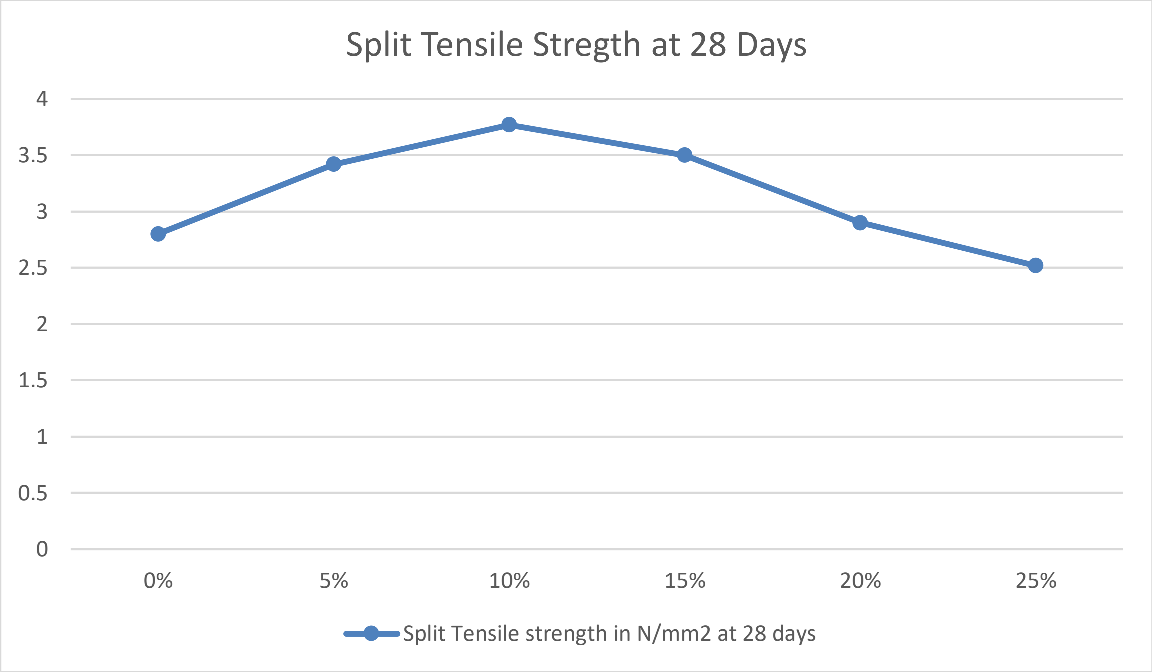

Figure 5.2.2.Split Tensile strength of concrete at 28 days

Figure 5.1.3.Split Tensile strength testing of concrete

The tables and charts above shows that the experimental investigation demonstrates that partially replacing cement with sugarcane bagasse ash in concrete, particularly at a 10% replacement level, offers promising results in terms of strength, waste reduction, carbon dioxide emission reduction, and economic benefits. These findings support the adoption of SCBA as a viable alternative material in concrete production, promoting sustainable and environmentally friendly construction practices.

6. Conclusions

The experimental investigation into the partial replacement of cement with sugarcane bagasse ash (SCBA) in M35 concrete has yielded valuable insights into its potential advantages. Initial material tests confirmed the quality and suitability of the concrete mix components, meeting essential standards. By casting cubes and cylinders with varying SCBA replacement levels (ranging from 0% to 25%), the study aimed to evaluate SCBA's impact on concrete strength and durability. Multiple samples were cast for each replacement level to ensure data reliability. Compressive and tensile strength tests were conducted at the 14th and 28th days post-casting, standard evaluation periods for concrete strength and durability. The results demonstrated that the highest compressive and split tensile strengths were achieved at a 10% replacement level, indicating that partial cement replacement with SCBA can yield satisfactory mechanical properties. Beyond strength benefits, SCBA use in concrete offers several advantages. It reduces carbon dioxide emissions by utilizing a sugarcane industry by-product, aligning with sustainability practices and environmental mitigation. Moreover, it reduces waste by repurposing a by-product that would otherwise be discarded.

Furthermore, partial cement replacement with SCBA presents economic advantages, reducing costs and improving fresh concrete workability without requiring super-plasticizers in some cases. Adjustments in the water-cement ratio can maintain desired workability while preserving strength characteristics, contributing to cost-effectiveness and quality control.

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