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Sugarcane Bagasse Ash Addition has a Positive Impact on Both the Fresh and Hardened Properties of Cement Concrete

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***Abstract*: The demand for and consumption of cement are rising as the building industry expands quickly. Cement manufacture takes a lot of raw resources, which results in carbon dioxide emissions into the atmosphere and other environmental issues. There has been a lot of research done in an effort to create substitute binders that are eco-friendly and aid in waste management. The bagasse, or fibrous waste product, is produced in large quantities by the sugar processing companies and dumped on open ground. Utilizing trash and its by-products as a disposal alternative has grown more appealing as environmental awareness has grown. Pozzolanic qualities are present in sugarcane bagasse ash, which mostly comprises silica and aluminium ions. During hydration, the silica in the bagasse ash interacts with the cement's ingredients. In the current development, an effort has been made to partially substitute cement with bagasse ash. The primary goal of this research is to examine the qualities of M-30 grade control concrete while it is both fresh and hardened. Bagasse ash has been substituted in concrete in amounts of 0%, 5%, 10%, 15%, 20%, and 25% by cement weight. Slump testing is done to investigate the new qualities. Compressive and split tensile strength tests are carried out to examine the hardened characteristics of concrete, and comparison research will be done.**

***Keywords*: Bagasse ash, compressive strength, split tensile strength, sugarcane bagasse ash, slump test, fine aggregate.**

1. Introduction

Concrete is a composite material made by combining cement, aggregates, water, and occasionally an additive if necessary. It goes through several processes, including handling, laying, and curing. The consistency of concrete is aided by inspection and control at every stage, from the acquisition of raw materials through the creation of the finished product.

Four elements make up concrete, and they may be divided into two categories. groups that are active and inactive. Water and cement are the members of the active group. Aggregates in both fine and coarse sizes make up the inactive category. Bagasse ash, a byproduct of the sugar industry, is burned to produce the energy needed for various manufacturing tasks. Bagasse is burned to produce bagasse ash, a waste product with pozzolanic properties that might be used in place of cement. It is well known that more than 1500 million tonnes of sugarcane are produced annually in the world. The disposal of bagasse ash will be a serious issue because sugarcane contains about 30% bagasse, whereas the amount of sugar recovered is only about 10%, and the bagasse produces about 8% bagasse ash as a waste (this number depends on the quality and type of the boiler, as modern boilers release less bagasse ash). In recent tests conducted in several regions of the world, sugar cane bagasse ash was discovered to increase some paste, mortar, and concrete qualities, including compressive strength and water tightness in specific replacement percentages and fineness. It was hypothesised that the fundamental reason for these benefits was the greater silica concentration in bagasse ash. It has been reported that the silicate undergoes a pozzolanic reaction with the cement's hydration products, which lowers the amount of free lime in the concrete, even though the silicate content can vary from ash to ash depending on the burning conditions and other properties of the raw materials, such as the soil on which sugarcane is grown.

2. Literature Review

U.R. Kawade and colleagues (2013) conducted research on the "Effect of Use of Bagasse Ash on Strength of Concrete." They chemically and physically characterised the bagasse ash and substituted some of it with cement in the proportions of 0%, 10%, 15%, 20%, 25%, and 30%. The findings demonstrate that the compressive strength of the SCBA concrete was much higher than that of the control concrete. It has been determined that SCBA can replace cement with an advantage up to a maximum of 15%. Although 15% replacement was sufficient to reach the ideal SCBA content level. Super Plasticizer is not required since partial cement substitution with SCBA improves the workability of fresh concrete. [1] In 2010, Mr. R. Srinivasan and colleagues looked into "Experimental Study on Bagasse Ash in Concrete." They had seen that sugar cane bagasse, a fibrous waste product of the sugar refining industry that mostly contains aluminium ions and silica and causes major environmental problems, was an issue. Hear bagasse ash has been chemically and physically described, and it has been used for cement in concrete at several degrees (0, 5, 15, and 25%). In addition to hardened concrete tests like compressive strength,

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split tensile strength, flexural strength, and modulus of elasticity at the age of seven and 28 days, fresh concrete tests like compaction factor test and slump cone test were also conducted. The findings demonstrate that, as compared to concrete without SCBA, blended concrete with SCBA had considerably better compressive strength, tensile strength, and flexural strength. It has been determined that SCBA can favourably replace cement up to a 10% maximum. The workability of fresh concrete is increased by partially replacing the cement with SCBA; hence, little super plasticizer is used. With an increase in SCBA concentration, concrete loses density.

3. Experimental Work's Objectives

The current experimental study has the following goals:

- Conduct a slump test to examine the initial characteristics of concrete built using sugarcane bagasse ash as a partial replacement for cement.
- Compressive and split tensile tests are carried out to examine the hardened characteristics of concrete built using sugarcane bagasse ash as a partial substitute of cement.

The following designation mix are used for current experimental study:

- M0: Control concrete without the inclusion of bagasse ash is referred to as M0.
- M1: In M1, 5% bagasse ash is used together with 95% cement.
- M2, which stands for the 10% bagasse ash and 90% cement admixture.
- M3, which denotes the inclusion of 20% bagasse ash and 80% cement.
- M4, where M4 denotes the inclusion of 15% bagasse ash and 85% cement.
- M5: is a mix that consists of 75% cement and 25% bagasse ash.

4. Method and Materials

A. Materials

The current work makes use of the following resources:

In this experimentation programme, cement of grade 43 with a specific gravity of 3.1 and in compliance with IS: 8112-2013 was used. In this testing programme, local river sand with a specific gravity of 2.60 and a zone II IS: 383-2016 classification was employed. Granular aggregate: Used were crushed angular aggregates with a specific gravity of 2.655. Water was absorbed at a rate of 0.4%.

Water: To prepare specimens and cure specimens, potable tap water is utilised. Ash made from sugarcane bagasse: kukkuvada, Davanagere Sugar Company Limited.

B. Methodology

According to IS 10262:2019, the mix design for M-30 grade concrete is done in the ratio 1:1.63:2.83. All the components were thoroughly combined to create the concrete. The necessary amount of water (w/c=0.44) was added to this dry mixture, and the entire mass was once more well mixed. The examples were given a smooth finish after the wet concrete was poured into the moulds and hand-compacted in three layers. The specimens were de moulded and sent to curing tanks where they were allowed to cure for the necessary number of days after 24 hours. The specimens used to measure compressive strength have dimensions of 150 mm, 150 mm, and 150 mm. They were evaluated using a 3000 kN compressive strength testing equipment in accordance with IS: 516-1959. The compressive strength is calculated by using the following equation,

$$F=P/A$$

Where, F is the specimen's compressive strength (in MPa)
P = the highest load placed on the specimen (in N)
A represents the sample's cross-sectional area (in mm^2)

A cylindrical specimen with a 150 mm diameter and 300 mm length was produced for the evaluation of split tensile strength. On a compression testing machine with a 3000 kN capacity, a split tensile strength test was performed in accordance with IS: 5816-1999. The following equation is used to compute the split tensile strength:

$$F=2P/(\pi DL)$$

Where, F is the specimen's split tensile strength (in MPa)
P equals load at failure (in N)
L is the cylindrical specimen's length (in millimetres), and D is its diameter (in mm).

5. Concrete Tests

A. Tests for Slumps on New Concrete

The concrete slump test gauges how fluid new concrete is before it hardens. It is done to examine whether freshly poured concrete is workable and, consequently, if concrete flows easily. It can also be used as a sign of a batch that was not properly blended. A steel mould in the shape of a cone with inside dimensions of 10 cm at the top, 20 cm at the base, and 30 cm overall makes up the Slump Cone Test.

B. Compressive Strength Test on Hardened Concrete

The ability of a substance or constitution to endure axial weights that tend to diminish the scale is known as compressive strength. Utilizing a compression testing machine (CTM), it is measured. Compressive force for assessing, mould dimensions of (150x150x150) mm, compression testing apparatus as indicated in Fig. 1.

According to Indian Standard 516-1959, the capacity of the compression testing equipment is 3000 kN.

C. Split Tensile Strength Test

A 300mm-tall, 150mm-diameter cylinder specimen was cast to test the split tensile strength. According to Indian Standard 5816-1999, the spilt tensile test was performed using a compression testing machine with a 3000 kN capacity (Fig. 1).

Fig. 1. Compression testing machine

6. Results and Analysis

The findings of the slump test are shown in Table 1.

Table 1
Slump test values

S. No.	Mix designation	Slump in mm
1	M0	95
2	M1	105
3	M2	100
4	M3	95
5	M4	90
6	M5	85

The compressive test is performed on cubes that are 150 mm in size. The compressive strength results for various mixtures after 28 and 56 days of curing are shown in Table 2, Fig. 2 and Fig. 3.

Table 2
Compressive strength of concrete

S. No.	Mix designation	Compressive strength (MPa)	
		28 Days	56 days
1	M0	34.2	34.81
2	M1	38.3	39.33
3	M2	23.85	28.44
4	M3	16.81	22.22
5	M4	10.2	13.31
6	M5	8.88	9.48

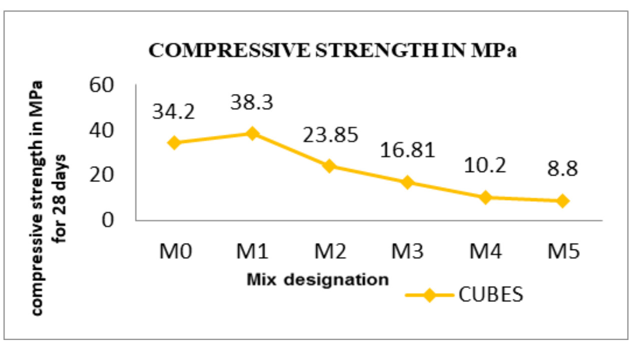

Fig. 2. Compressive strength of concrete for 28 days

Table 3
Split tensile strength of concrete

S. No.	Mix designation	Split tensile strength (MPa)	
		28 Days	56 days
1	M0	2.6	2.71
2	M1	2.87	3.08
3	M2	2.45	1.98
4	M3	1.76	1.39
5	M4	1.1	1.01
6	M5	0.99	0.58

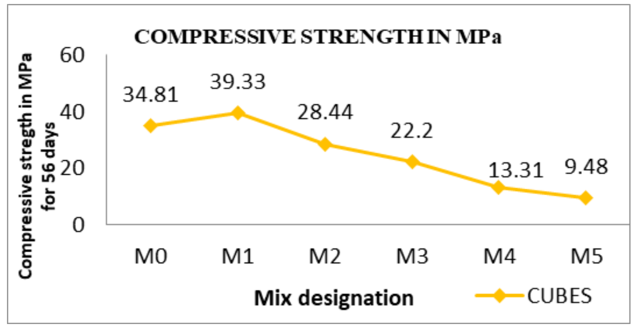

Fig. 3. Compressive strength of concrete for 56 days

A 150mm diameter and 300mm height cylinder is used for the split tensile test. Table 3, Fig. 4 and Fig. 5 show the split tensile strength values for various combinations after 28 and 56 days of curing.

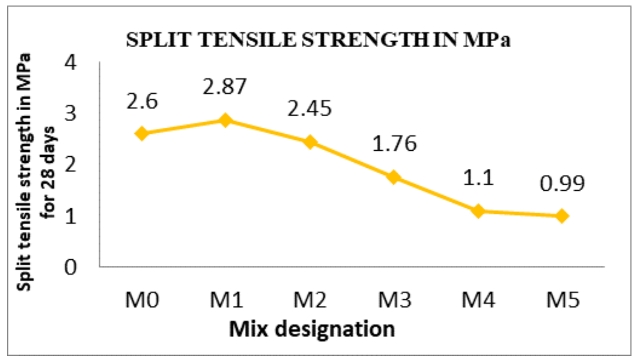

Fig. 4. Split tensile strength of concrete for 28 days

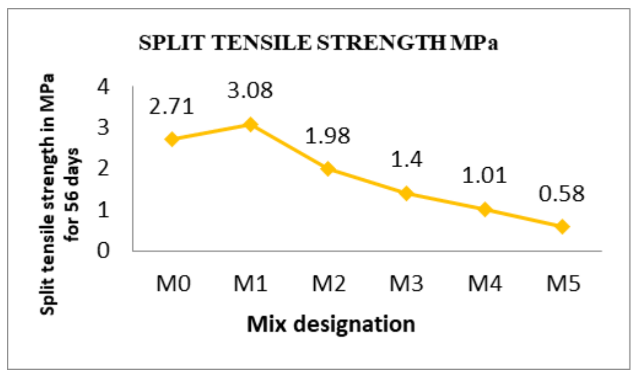

Fig. 5. Split tensile strength of concrete for 56 days

7. Observations and Discussions

The influence of sugarcane bagasse ash on cement concrete is examined in the current work, and the results of the tests conducted led to the following conclusions.

The test findings demonstrate that adding sugarcane bagasse ash improved the workability.

The workability of concrete prepared with sugarcane bagasse ash was higher than that of a typical mix. The compressive strength rose as the replacement amount of sugarcane bagasse ash increased after 28 days of cure. Mixtures M1, M2, M3, M4, & M5 had 12% greater compressive strengths (30.26%, 50.8%, 70.17%, & 74.26% in -ve). Among all mixtures, Mix M1 had the maximum compressive strength. Additionally, throughout the 56-day curing period, when the replacement amount of sugarcane bagasse ash rose, the compressive strength improved. Mixes M1, M2, M3, M4, & M5 had 12% greater compressive strengths (18.22%, 36.2%, 61.7%, & 72.7% in -ve). Among all mixtures, Mix M1 had the maximum compressive strength.

At the end of the 28-day curing period, the split tensile strength of the mixtures M1, M2, M3, M4 and M5 is 10.3% higher (5.7%, 32.3%, 57.6%, and 61.9% in the negative). Among all mixtures, Mix M1 had the greatest split tensile strength. Additionally, after 56 days of curing, the split tensile strength of the mixture M1, M2, M3, M4 & M5 has increased by 13.6% (26.9%, 48.3%, 62.7%, and 78.5% in -ve). Among all mixtures, Mix M1 had the maximum compressive strength. According to the findings of the experiments, concrete constructed with sugarcane bagasse ash performs better than control concrete in terms of compressive strength and split tensile strength. The fact that strength increased along with replacement level, however, demonstrates that sugarcane bagasse ash can be employed in any combination. Since all blends outperformed control concrete in terms of performance. However, mix M1, in which sugarcane bagasse ash replaces some of the cement, can be utilised to improve the durability of concrete created with the material.

8. Conclusion

- Sugarcane bagasse ash added to the concrete makes it easier to work with.
- The findings of the compression test indicate that M1 mixes are producing better outcomes than control concrete up until that point. However, M1 mix is displaying the best outcome.
- Results for split tensile strength indicate that all of the mixtures are outperforming control concrete. However, the mix M1 is displaying the best outcome.
- Sugarcane bagasse ash may be used in place of some of the cement. Comparing these two materials to manage concrete, they will produce the best outcomes.

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