EXPERIMENTAL INVESTIGATION OF POLYPROPYLENE FIBER AND STEEL FIBRE IN ENGINEERED CEMENTITIOUS COMPOSITES

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ABSTRACT

Global warming is one of the biggest environmental problems the modern world is experiencing, and increasing cement manufacturing is a major contributing factor. Investigating substitute materials with pozzolanic qualities with the objective to use less cement is one way to mitigate this effect. Maintaining structural strength at the identical time is essential to withstanding long-term environmental conditions. The purpose of this research is to determine how the structural belongings of concrete stand affected when bagasse ash is substituted for portion of the binder and when polypropylene and hooked steel fibers are added at the ideal ratio. M40 grade concrete trials stayed cast with replacement ratios of 10%, 15%, and 5% bagasse ash. Furthermore, different amounts of hooked steel and polypropylene fibers were added, ranging from 0.5% to 2% with a 0.5% increase and 0.50% to 1.25% with a 0.25% increment, respectively.

Keywords: Steel fibers, PPF, mechanical properties.

I. INTRODUCTION

Globally, the construction business is expanding quickly, and one essential element in this industry is concrete. When concrete is new, it is pliable and flexible; as it sets, it becomes strong and long-lasting. Durability, impermeability, and fire resistance, along with to good compressive strength, moldability, plasticity, and flowability in its fresh state, contribute to its extensive application in the making of stadiums, retaining structures, structures like bridges and dams, pavements, and more. In traditional concrete, the typical binding ingredient is Ordinary Portland Cement (OPC). Unfortunately, the energy-intensive OPC manufacturing process releases a significant quantity of greenhouse gases, such as methane (CH4) and carbon dioxide (CO2), which are key causes of global warming. Around one tonne of greenhouse gases is created for every tonne of OPC produced, which accounts for 5-8 percent of CO2 emissions worldwide. A worsening of this environmental problem is a real possibility because to the growing request for OPC. To try to solve this, scientists are investigating the possibility of other admixtures, such as agricultural and agro-industrial by-products like bagasse ash, to replace OPC entirely or in part in the production process of concrete without sacrificing the material's quality.

This environmentally friendly method decreases waste and lowers building expenses although also having confident effects upon the ecosystem. Especially in India, there are obstacles to efficient recycling and garbage management. When incorrectly disposed of, industrial and farming by-products, such as bagasse ash, contribute to contamination of the environment. The residue of burning sugarcane bagasse, bagasse ash, may pollute the air and water when it is disposed of in an open area. Finding sustainable alternatives to OPC is a vital component in fixing these problems and making the building sector more eco-friendly.

1.2 The investigation's goals

1.2.1 General objectives:

This study's main objective is to ascertain if sugarcane bagasse ash is readily available in India and whether utilizing it as a cement alternative in sugar mills is feasible. Examining the strength parameters of steel and PPF reinforced concrete utilizing 0%, 0.5%, 1%, 1.5%, and 0%, 0.25%, 0.5%, 0.75%, 1%

1.2.2 Specific objectives:

This analytical work aims to achieve the following specific goals:

- ❖ Assessing the availability of bagasse ash and fibers in the country.
- ❖ Examining the chemical composition of bagasse ash.
- ❖ Estimating the optimal quantity of bagasse ash for efficient utilization and conducting laboratory tests on paste, mortar, and concrete using bagasse ash as a replacement material, both in fresh and hardened states.
- ❖ Evaluating the strength characteristics by individually substituting a portion of bagasse ash concrete with steel and polypropylene fibers.
- ❖ Finally, providing findings and recommendations founded on the performance and various attributes of sugarcane bagasse ash and fibers as a substitute for cement.

2. MATERIAL COLLECTION

The project utilized various materials, each explained in detail. The materials include:

1. Cement
2. Fine aggregate
3. Coarse aggregate
4. Bagasse ash
5. Steel fibers
6. Polypropylene fibers

2.1. Cement:

Cement is a crucial component in concrete production, serving as the binding agent due to its pozzolanic characteristics. It binds the fine and coarse aggregates together, creating a cohesive structure. As concrete strength increases, the water-to-cement ratio decreases. Two commonly used types of cement are:

- OPC
- PPC

Fig 1: Opc 53 Grade Cement

Grade 53 OPC is employed for the creation of this assembly. The cement exhibits a greyish-green color, and its composition is free from lumps or other irregularities. Proper storage measures are implemented to prevent exposure to the basics and the introduction of moisture when packing cement bags. The alternative material for additional cementitious materials is bagasse ash, which is used in different percentages to the cement content: 0%, 5%, 10%, and 15%. Procedures for cement testing include soundness, specific gravity.

Table 1: Test outcomes of Traditional cement

S. No	property	Test Results
1	Normal consistency	30%
2	Specific gravity	3.10
3	Fineness modulus	7.3%
4	Initial setting time	30 minutes
5	Final setting time	570 minutes

2.2 Fine Aggregate:

Sand, a obviously occurring rough substance composed of finely divided rock and mineral particles, constitutes over 85% of soil particles. It finds applications in mortar, concrete, cleaning, and sandblasting. With a weight ranging from 1538 to 1842 kg/m³ depending on ounce content and size, sand is a versatile material. For this experiment, fine aggregate sourced from a riverbed, free from organic contaminants, was used. The fine aggregate, passing through a 4.75mm screen, had a sp. gravity of 2.68. It complied with Indian Standard standards, falling within zone II for fine aggregate grading. Locally available fine material was utilized for specimen preparation, and the FA sieve analysis followed ASTM C-136-04 standards. The FM was found to be 2.56, within the permissible limit, and the typical grain size was 600 micrometers. The sp. gravity of the fine aggregate was determined using ASTM C-158, resulting in a calculated value of 2.68.

Fig 2: Fine aggregate

Table 2: Fine aggregate's physical characteristics

S. no	Characteristics	VALUE
1	Moisture content	1.4%
2	Specific gravity	2.68
3	Zone of sand	Zone II

2.3 Coarse aggregate

CA characterized by particle sizes larger than 4.75mm, constitutes roughly 60 to 80 out of each hundred of the entire volume in conventional concrete. Choosing long-lasting aggregates is vital to guaranteeing optimal effectiveness, uniform concrete strength, and workability. An ideal aggregate must be sturdy, angular, and barren of contaminants and dangerous substances. Concrete becomes stronger when the subdivisions are sorted properly, which lessens the requirement for cement paste to fill in gaps. Less cement and water are needed when using well-graded aggregates, which improves strength, decreases shrinkage, increases durability, and allows for more economical construction. For this project, angular quarry aggregates with a scope of 20mm were employed.

Fig 3: 20 mm size coarse aggregate

Table 3: Coarse aggregate's physical characteristics

S. No	Characteristics	VALUE
1	Moisture content	1.4%
2	Specific gravity	2.68
3	Sand	Zone II

2.4 Sugar Cane Bagasse Ash:

The material that remains after sugarcane is incinerates is called bagasse ash from sugar cane. Since of its chemical makeup, this waste may be used to partially change cement. The Indian state of Telangana provided the B ash, which came from the Karimnagar area. The moisture level of the B ash that is removed from the production is typically between 40 and 50 percent. Bagasse is one waste material that is burnt to create energy for various industrial processes.

As shown in figure 3.2.4, the bagasse, which is utilized as fuel in the boilers, is cooked at temperatures between 500 and 800 degrees Celsius to produce BA. After being poured onto a neighboring tract, the heated ash was mutual with liquid and allowed to cool. After it cooled, the ash was supplied in package bags. after oven drying for around 12 hours to eliminate any moisture, the collected ash was standardized by passing it through a 300 m sieve.

Fig.4: Sugarcane bagasse ash

Table 4: The physical constitution of bagasse ash

Particulars	Outcomes
Sp. gravity	1.975
Fineness	2.536%
Color	BLACK
Particle	Powder from
Bulk density	87.2kg/m3
Moisture	11.5%

2.5 Steel fibers:

The volume fraction, denoted as Vf, represents the proportion of the overall volume of the composite (fibers and concrete) attributable to the fiber additions. Typically, Vf falls within the range of 0.12 to 3%. The aspect ratio of non-circular fibers is commonly calculated using an equivalent diameter, and it's crucial to avoid excessively long fibers that may lead to workability issues. The outcomes of this investigation show that the enclosure of fibers hardly affects the impact resistance of the concrete. In this project, hooked steel fibers measuring 36mm in length were employed. These steel fibers have an part ratio of 80mm and a density of 7850kg/m3.

Fig 5: steel fiber

Table 5: The physical constitution of Steel fibers:

Particular	Results
Aspect ratio	20-100
Length	6.5-80mm
Dia	0.25-0.71mm
Tensile strength	275-2760mpa
Young's modules	200*103 mpa
Ultimate elongation	0.5-35%

2.6 Polypropylene fibers:

Polypropylene fibers are often grouped into two types: micro and macro-PP fibers. For this trial, a small type of (PPF) with dimensions of 6mm in width and 12mm in length was utilized. The primary purpose of PP fibers is to modify the characteristics of fresh concrete. They contribute to stabilizing the movement of solid particles, enhancing the uniformity of the mix. This reduction in bleed capacity and bleed rate helps minimize plastic settling. Furthermore, when the concrete surface dries out too soon, plastic shrinkage cracking may develop. This is something that the fiber matrix helps to avoid.

Fig 6: Polypropylene fibers

Table 6: Properties of PPF

Property	Test data
Width	8mm
Length	14mm
Fiber denier	6+/-10%
Breaking tenacity	4.4+/-10%
Breaking elongation percentage	100+/30%
Melting point	170-175
Specific gravity	0.95

2.7 Water:

Water is required for the mixing and curing processes. There shouldn't be any harmful levels of oil, acids, alkalis, or other inorganic and organic contaminants. It should also be free of iron, plant waste, and any other substances that might harm the reinforcement or concrete. The water used to mix concrete should adhere to drinking water regulations.

III. MIX DESIGN

3.1 MIX PROPORTIONS

Table 7 Mix proportions of Concrete

MATERIAL	WEIGHT
Cement	492.900 kg/m3
Fine aggregate	732.98 kg/m3
Coarse aggregate	1027.02 kg/m3
Water	197.16 liters
Water cement ratio	0.4

3.2: Mix details for concrete:

Table 8: **Percentage of Bagasse ash**

Material	0%BA	5%BA	10%BA	15%BA
Cement	492.960	468.312	443.664	419.016
Bagasse ash	0	24.648	49.296	73.944
Fine aggregate (kg/m3)	732.98	732.98	372.98	732.98
Coarse aggregate (kg/m3)	1027.02	1027.02	1027.02	1027.02
Water(liters)	197.16	197.16	197.16	197.16
W/C Ratio	0.4	0.4	0.4	0.4

Table 9: Percentage of steel fibers

Materials	BASF-A	BASF-B	BASF-C	BASF-D
Cement	468.312	468.312	468.312	468.312
Steel Fibers(kg)	0.5%	0.75%	1.00%	1.25%
Fine Aggregate	732.98	732.98	732.98	732.98
Coarse Aggregate	1027.02	1027.02	1027.02	1027.02
Water(lit)	197.16	197.16	197.16	197.16

Table 10: Percentage of Polypropylene fibers

Material	BAPPF-A	BAPPF-B	BAPPF-C	BAPPF-D
Cement	468.312	468.312	468.312	468.312
PPF	0.5%	1.00%	1.5%	2.0%
Water	197.16	197.16	197.16	197.16
Fine aggregate	732.98	732.98	732.98	732.916
Coarse aggregate	1027.02	1027.02	1027.02	1027.02

3.3 Casting and Curing of Mould:

The experimentation phase of the project commences at this point. Everything we have undertaken in the mix design calculation up to this stage has been theoretical. Once the mix ratio is established, the casting of cubes, cylinders, and prisms is carried out in this step. The casting in this experiment is performed through manual mixing.

IV.RESULTS AND DISCUSSIONS

The results of laboratory tests pertaining to the potential of bagasse ash as a cement substitute are presented and assessed in this section. The investigation examines many bagasse ash characteristics, including the consistency and setting time of pastes that have been combined with different proportions of bagasse ash substituted in them. The workability of concrete that has varied bagasse ash replacement levels. Additionally, we provide test results for the concrete's split tensile, flexural, and compressive strengths.

4.1 Compressive strength of concrete:

The most popular kind of test for hardened concrete is the compressive strength test. Compared to other concrete qualities, compressive strength testing is very simple, and it serves as the basis for several principles and strategy recommendations. Every concrete cube is verified in a CTM to ascertain its compressive strength. Each blend's compressive strength is intended as the mean of three trials.

M40 concrete compressive strength with various percentages of Bagasse ash

Table 11: Compressive strength standards of concrete

S.NO	Percentage of Bagasse ash	Compressive strength(N/mm2)	
		7days	28days
1	0	38.15	50.05
2	**5**	41.05	**55.23**
3	10	40.84	54.81
4	15	40.500	54.050

When bagasse ash was added to concrete at a rate of 5% instead of cement, the concrete reached its maximum compressive strength.

Table 12: Strength of M40 concrete with different amounts of steel fiber and the ideal amount of B ash

Optimum % of BA	Percentage of steel fibers	Compressive strength(N/mm2)	
		7days	28days
5%	0.5	46.65	59.13
	0.75	46.51	60.05
	1.00	47.10	**61.63**
	1.25	46.93	60.95

From the table 12 the strength of concrete with varying steel fiber percentages and the recommended dosage of 5% bagasse ash. One percent was the optimal amount of steel fibers in concrete.

Table 13: M40 concrete with a variable percentage of polypropylene fibers and an ideal percentage of bagasse ash.

Optimum % of BA	Percentage of PPF	Compressive strength(N/mm2)	
		7days	28days
5%	0.5	45.90	54.15
	1.00	46.27	59.32
	1.5	**47.08**	**60.84**
	2	46.74	59.79

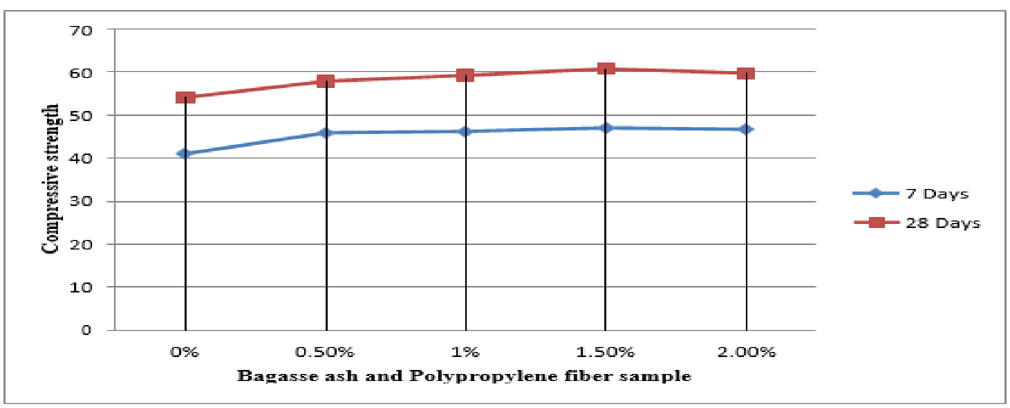

Fig. 7: M40 concrete with varying amounts of polypropylene fiber and the ideal amount of bagasse ash

The graph above illustrates the compressive strength of concrete that contains varying percentages of glass fibers and up to 5% bagasse ash. 1.50 percent of steel fibers were added to the concrete to increase its maximum compressive strength.

4.2 Split Tensile Strength Test:

Table 14: M40 concrete split tensile strength with the optimal percentage of bagasse ash

S.NO	% of Bagasse Ash	28 Days
1	0%	2.45
2	**5%**	**2.68**
3	10%	2.56
4	15%	2.48

At various percentages of Bagasse ash is shown in the table. The concrete attained its optimum compressive strength when 5% of the cement was replaced with B ash

Table 15: M40 concrete SPT strength with optimal percent Bagasse ash and variable percent steel fibres

Optimum % of BA	% of Steel fibers	28 Days
5%	0.5%	3.04
	0.75%	3.16
	1.00%	3.28
	1.25%	2.93

The following graph illustrates the SPT strength of concrete with changing amounts of steel fibers and up to 5% bagasse ash. One percent was the optimal amount of steel fibers in concrete.

Table 16: M40 concrete SPT strength with varying polypropylene fiber fractions and the right quantity of bagasse ash

Optimum % of BA	% of Steel fibers	28 Days
5%	0.5%	2.85
	1.0%	3.16
	1.5%	3.18
	2.0%	3.19

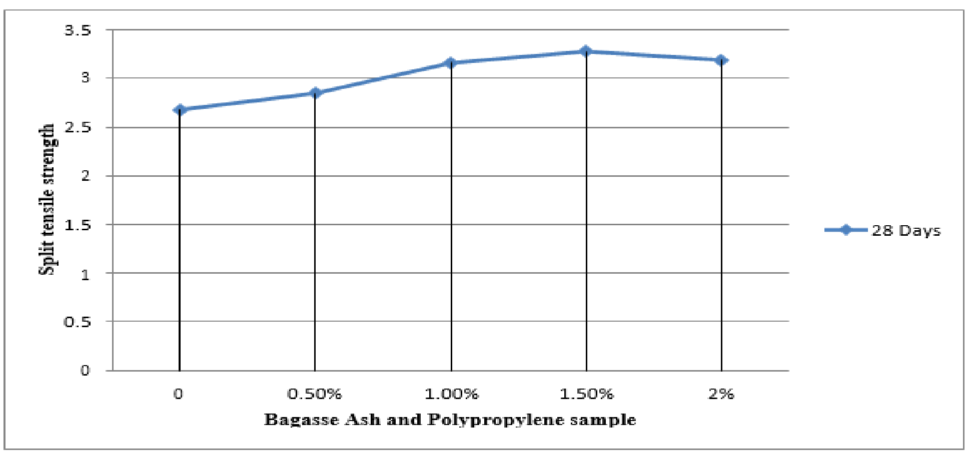

Fig. 8: M40 concrete split tensile strength with a variable percentage of polypropylene fibers and an ideal percentage of bagasse ash

The graph overhead illustrates the SPT strength of concrete at various polypropylene fiber percentages and optimal bagasse ash (5%) content. At 1.5 percent polypropylene fibers, the SPT strength of the concrete was optimal

4.3 Concrete flexural strength

Following the compilation of test data for concrete's flexural strength, the graphs below were created.

Table 17:M40 concrete flexural strength with optimal Bagasse ash content

S.NO	% of Bagasse Ash	28 Days
1	0%	9.58
2	5%	9.61
3	10%	9.42
4	15%	9.45

The flexural strength of concrete at various fractions of B ash is shown in the above table. The flexural strength of the concrete was optimized at 5% fractional cement substitution with bagasse ash.

Table 18: Flexural strength of M40 concrete with different fractions of steel fibers and an ideal percentage of B ash

S.NO	% of Steel fibers	28 Days
1	0.5%	9.81
2	0.75%	10.1
3	1.00%	10.25
4	1.25%	10.43

The following graph illustrates the flexural strength of concrete with up to 5% B ash and various concentrations of steel fibers. At 1.0 out of a hundred steel fibers, the optimal flexural concrete's strength was achieved.

Table 19: Flexural strength of M40 concrete with different proportions of polypropylene fibers and an ideal ratio of bagasse ash

S.NO	% of Polypropylene Fiber	28 Days
1	0.5%	7.79
2	1.0%	7.83
3	1.5%	7.95
4	2%	6.58

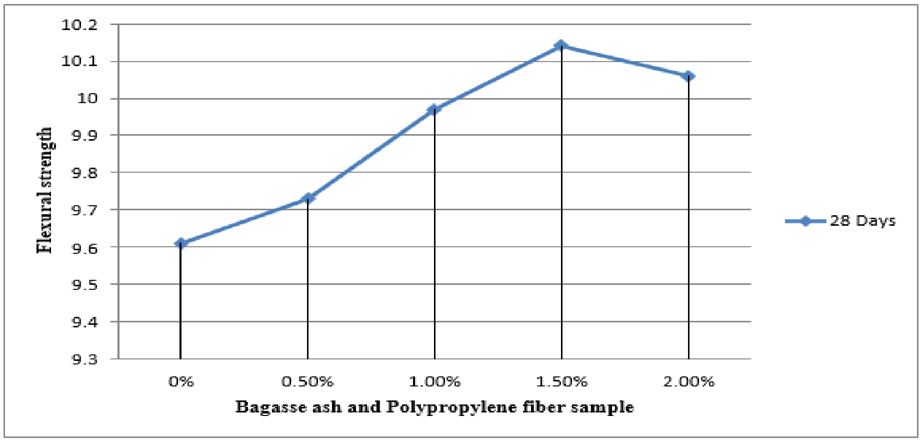

Fig. 9: Flexural strength of M40 concrete with different proportions of polypropylene fibers and an ideal ratio of bagasse ash

The chart overhead illustrates the flexural forte of concrete with varying polypropylene fiber percentages and the recommended dosage of B ash (5%). Concrete was optimized for compressive strength by including 1.50 percent polypropylene fibers.

V. CONCLUSION

After adding fibers and using bs ash in place of cement throughout the concrete-making process, the following conclusions were made:

- An extended setting time and a advanced standard consistency, signifying more water usage, were the outcomes of adding more bagasse ash substitutes.
- The workability of concrete containing bagasse ash diminishes somewhat as the concentration of bagasse ash rises because it wants extra water than other elements.
- When the amount of SCBA in the concrete increases, the density of the concrete falls.
- SCBA improved the compression strength of concrete up to 5% replacement; beyond that, the strength values fell.
- After 28 days of curing, the maximum increasing percentages of flexural strength, split tensile strength, and compressive strength are 7.57 percent, 0.7 percent, and 8.58 percent, respectively. The right amount of BA to OPC to replace OPC is five percent.
- Following 28 days of curing, the highest increasing percentages of compressive, flexural, and tensile strengths at BAC levels of 5% are 9.5%, 6.24%, and 18.29%, respectively. There is 1% steel fiber inclusion.
- After 28 days of curing, the maximum increasing percentages of tensile, flexural, and compressive strengths at BAC of 5% are 15.722%, 5.222%, and 9.22%, respectively, with 1.5 percent polypropylene integrated.

The study's findings indicate that steel fiber B ash concrete is further resilient than polypropylene Bagasse concrete

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