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An Investigation on Medium Grade Concrete Impregnated with Polypropylene Fiber and Sugarcane Bagasse Ash with PPC

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Abstract: ***The construction industry is increasingly focusing on sustainable materials to reduce the environmental impact associated with cement production. Sugarcane Bagasse Ash (SCBA), an agricultural waste generated from sugar industries, possesses pozzolanic characteristics and can be utilized as a partial replacement of cement. Polypropylene Fiber (PPF) is known for improving tensile strength, crack resistance, and durability of concrete. This study investigates the combined effect of SCBA and PPF on M40 grade concrete prepared using Portland Pozzolana Cement (PPC). SCBA was used as a partial replacement of cement at 5% and 8%, while polypropylene fibers were incorporated at 0.5%, 1.0%, and 1.5% by volume. The experimental program included slump test, compressive strength test, split tensile strength test, and permeability test. Results indicated that the mix containing 5% SCBA and 1.0% polypropylene fiber exhibited optimum performance with a maximum compressive strength of 47 MPa at 28 days. The incorporation of SCBA and PPF improved mechanical properties and reduced permeability, thereby enhancing durability. The study demonstrates the feasibility of utilizing agricultural waste and synthetic fibers to produce sustainable and high-performance concrete.***

Keywords: Sugarcane Bagasse Ash, Polypropylene Fiber, M40 Concrete, PPC, Compressive Strength, Split Tensile Strength, Permeability.

I. INTRODUCTION

Concrete is the most widely used construction material due to its versatility, durability, and economic advantages. However, cement manufacturing contributes significantly to greenhouse gas emissions. Therefore,the utilization of supplementary cementitious materials has become essential for sustainable construction.Sugarcane Bagasse Ash (SCBA) is a by-product obtained after burning sugarcane bagasse. Due to its high silica content (approximately 75.2%), it exhibits pozzolanic behavior and contributes to strength development in concrete. Polypropylene Fiber (PPF) is a synthetic fiber that improves crack resistance, toughness, and tensile properties of concrete. The combined utilization of SCBA and PPF can improve the performance of concrete while reducing environmental impact.

A fiber reinforced concrete enhances the compressive stress, strain and flexure and split tensile strength of concrete also acting as crack arrestor and reduce the propagation of cracks in concrete.

Fiber-reinforced concrete (FRC) that includes **bagasse ash**, a by-product of sugarcane processing, combines the advantages of both fiber reinforcement and the pozzolanic properties of bagasse ash.

This combination enhances the mechanical, durability, and environmental properties of concrete.

II. LITERATURE SURVEY

Several researchers have investigated the effects of polypropylene fibers and sugarcane bagasse ash on concrete properties.

1) Salahuddin Alsace and Mohsen Salem reported that polypropylene fibers increased compressive strength by 4–12%, with optimum performance at 2% fiber dosage.
2) Nishant Kumar and Ashutosh Sahu observed improvement in compressive and flexural strengths with increasing fiber content, although workability decreased.
3) Shruthi H.R. et al. found that 10% SCBA replacement produced maximum compressive strength.
4) R. Srinivasan reported that SCBA replacement up to 10% significantly improved compressive and tensile strength.

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Research Gap

Most previous studies investigated SCBA and polypropylene fibers separately. Limited research is available on the combined influence of SCBA and polypropylene fibers on M40 grade concrete prepared using PPC.

III. OBJECTIVE OF THE WORK

To study the combined effect of SCBA and polypropylene fibers on M40 concrete and evaluate compressive and split tensile strength characteristics.

IV. METHODOLOGY

Themethodologyused regarding theworkis as follow :

1) Identification and specificationofmaterialtobeselected.
2) Collect and identifyingthepropertiesofcollectedmaterials.Various tests were conducted on cement, fine aggregate, coarse aggregate.
3) Preparation of mix design of M40 grade concrete. 6)Cubes and cylinderwerecasted withcontrol mix using natural aggregate.
4) Preparationoftestspecimenbyadding0.5,1,1.5of polypropylene fibres in concrete mix with SCBA of 5% and 8%.
5) Workabilitytests,compressivestrength,tensilestrength of concrete were conducted.
6) Optimumpercentage of fibre addition in concrete was determined.

V. MATERIAL TEST

Table-1:MaterialTestingResults

Test	Material	Equipmentused	Values obtained
Specific gravity	PPC	Density Bottle	3.141
Initial setting time	PPC	Vicat apparatus	85 mins
Final setting time	PPC	Vicat apparatus	420 mins
Specific gravity	Fineaggregate	Pycnometer	2.348
Specific gravity	Coarse aggregate	Pycnometer	2.94
Water absorption	Coarse aggregate	Oven Dry Method	2.354 %
Workability	M340 Concrete	Slumpcone apparatus	100mm

VI. MIX DESIGN

Table-2:M40MixProportioning

Cement(Kg/m3)	450
Fineaggregate(Kg/m3)	580.14
Coarseaggregate(Kg/m3)	1290.59
Water(li/m3)	164.96
Watercementratio	0.37

Mixratio1:1.28:2.80:0.37

VII. EXPERIMENTAL INVESTIGATION

A. Test Procedure

For concretetestspecimensconsistof150x150x150mmcubes and Cylinders of 150mm diameter and 300mm height . Compressive strength was obtain on the basis of concrete cube specimen tested at 7 and 28 and for split tensile strength cylindrical specimens were tested at 28 day.

B. Testonfreshconcrete

On fresh concrete, workability testapply to check the affects of concrete strengthanddurabilityaswellastheappearance ofthefinishedproduct. For easily placed and well compacted in homogeneously without bleeding and segregation concreteis to be well workable. In this work the workability of concrete is measured by slump test.

C. Testonhardened concrete

To ensure the design strength of hardened concrete various test is to be done and quality of concrete construction is achieved. It includes compressive strength test,flexuraltensilestrengthtest,splittensilestrengthtest and modulus of elasticity.

VIII. EXPERIMENTAL RESULTS AND DISCUSSION

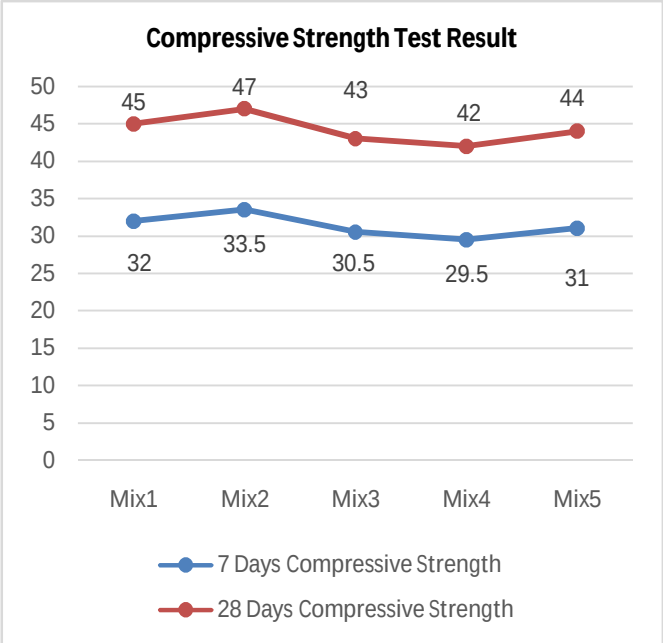
A. Optimizationofpolypropylenefiberin concrete

In this section polypropylene fiber and sugarcane bagasse ash of different percentage added in concrete.

Table-3: Mean Compressive Strength test result

Mix	% of SCBA	% of PP Fiber	Mean Compressive Strength (MPa)	
			7 Days	28 Days
Mix1	5	0.5	32.0	45.0
Mix2	5	1	33.5	47.0
Mix3	5	1.5	30.5	43.0
Mix4	8	0.5	29.5	42.0
Mix5	8	1	31.0	44.0
Mix6	8	1.5	28.0	40.5

Fig 1: Mean Compressive Strength test result

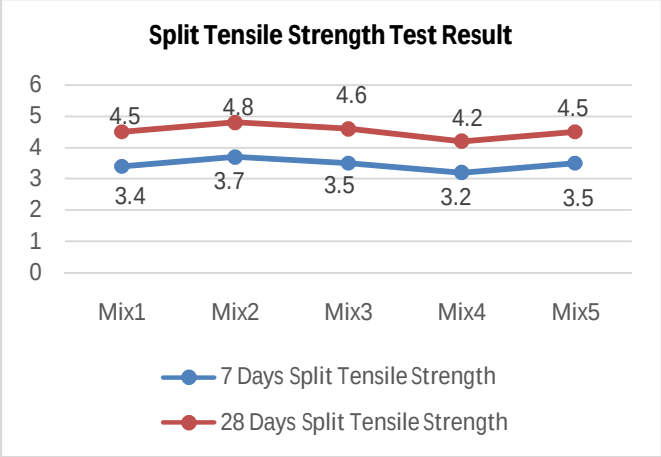


The above result show the maximum compressive strength is 47MPa at 28 days and 33.5Mpa at 7 days, which is Mix2. Compressive strength increases at 5% replacement of sugarcane bagasse ash with PPC in addition of mix with 1% of polypropylene fiber increase the bonding characteristics of concrete. On increase of sugarcane bagasse ash at 8%, the strength get decrease on addition of same percentage of polypropylene fiber.

Table-4: Mean Split tensile Strength test result

Mix	% of SCBA	% of PP Fiber	Mean Split Tensile Strength (MPa)	
			7 Days	28 Days
Mix1	5	0.5	3.4	4.5
Mix2	5	1	3.7	4.8
Mix3	5	1.5	3.5	4.6
Mix4	8	0.5	3.2	4.2
Mix5	8	1	3.5	4.5
Mix6	8	1.5	3.3	4.3

Fig 2: Mean Split Tensile Strength test result



The above result show the maximum split tensile strength is 4.8MPa at 28 days and 3.7MPa at 7 days, which is Mix2.
Split tensile strength increases at 5% replacement of sugarcane bagasse ash with PPC in addition of mix with 1% of polypropylene fiber increase the bonding characteristics of concrete. On increase of sugarcane bagasse ash at 8%, the strength get decrease on addition of same percentage of polypropylene fiber.

Permeability test result for all mix sample is as follow:

Table-5 Permeability Test Result After 28 days

Mix	SCBA (%)	PPF (%)	Depth of Penetration (mm)	Coefficient of Permeability ($\times 10^{-12}$ m/s)
Mix1	5	0.5	21	4.3
Mix2	5	1.0	18	3.8
Mix3	5	1.5	20	4.2
Mix4	8	0.5	18	3.6
Mix5	8	1.0	15	3.1
Mix6	8	1.5	17	3.5

The optimum mix was found that at 8% SCBA with 1.0% PPF, which produced the lowest water penetration depth and permeability coefficient, indicating a highly dense and durable concrete matrix.

IX. CONCLUSIONS

1) Based on the experimental results**,** 5% replacement of PPC cement with Sugarcane Bagasse Ash (SCBA) and 1.0% Polypropylene Fiber (PPF) is recommended for M40 grade concrete, as it provided the best overall mechanical performance.

2) The optimum mix achieved a 28-day compressive strength of 47 MPaand a split tensile strength of 4.8 MPa**,** indicating its suitability for structural concrete applications requiring enhanced strength and crack resistance.

3) The use of SCBA and PPF is recommended as a sustainable alternative in concrete production, as it reduces cement consumption and promotes the utilization of agricultural waste materials.

X. SCOPE OF FUTURE STUDY

Research can be extended to study the behavior under elevated temperatures and fire resistance, especially due to the presence of polypropylene fibers.

The use of chemical admixtures (superplasticizers, nano-materials like nano-silica) can be explored to further enhance workability and reduce permeability.

Advanced microstructural analysis using SEM, XRD, and FTIR techniques can be carried out to better understand pore refinement and bonding mechanisms.

The effect of curing methods (steam curing, self-curing, and accelerated curing) on permeability and microstructure of SCBA–fiber concrete can be studied.

Investigationontheflexuralandshearcrackpatternoffiber reinforced concrete.Comparativestudy on blended type, micro and macro length polypropylene fibers.

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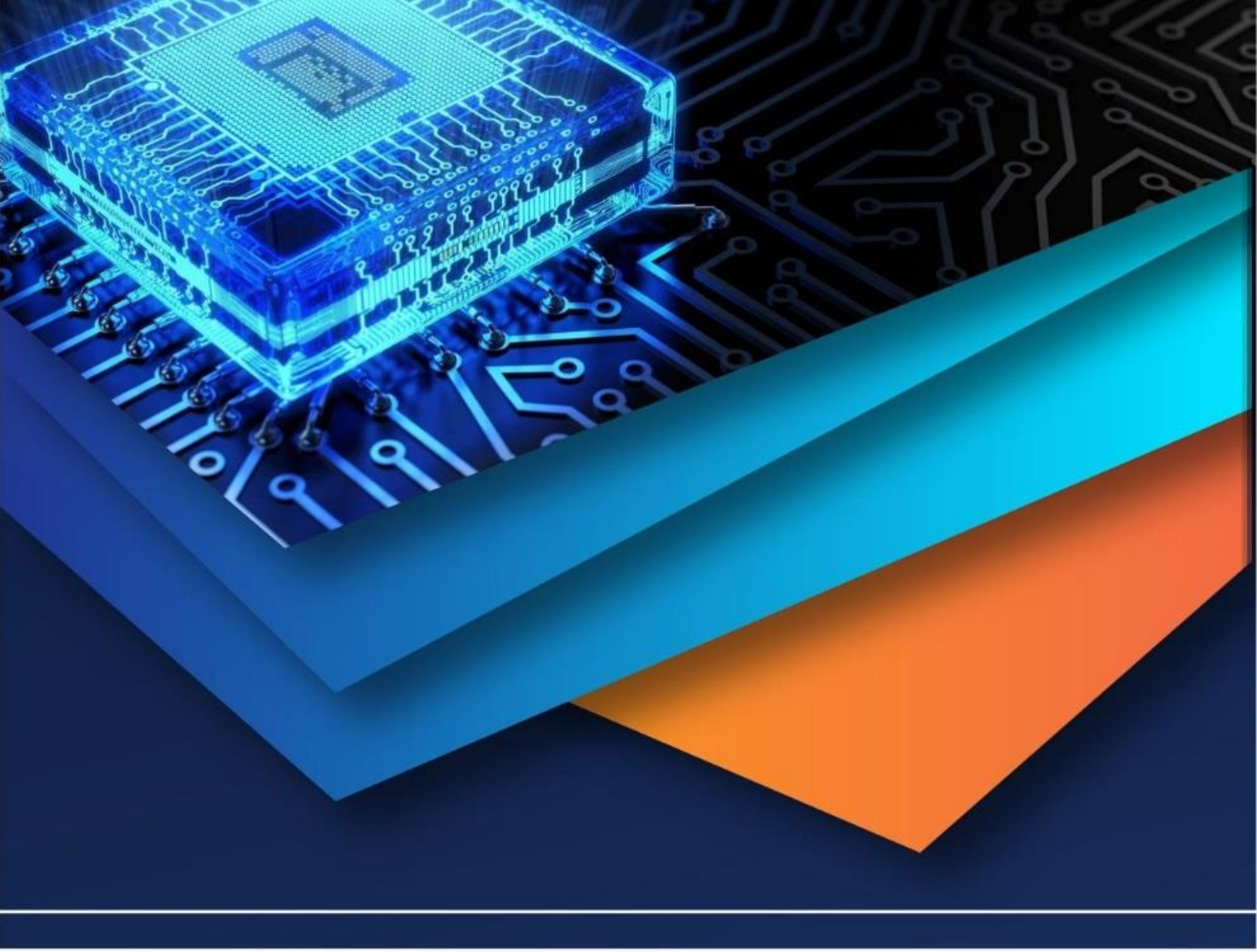

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