Effects of Partial Replacement of Fine Aggregate with Polypropylene & Jute Fiber of Different Ratio in Concrete M25 Grade

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Abstract: (Please read carefully abstract of the template). Jute fiber is a natural fiber that is an environmentally friendly material popularly known as golden fiber. Jute fiber is the most available fiber in India with fewer expenses. Polypropylene fiber is made by synthetic hydrocarbon polymer and has several advantages over other fibers; corrosion-resistant, durability, constructability with light-weight, abrasion resistant, chemical resistant. The aim of the study was to check the effect of using polypropylene and jute fiber in concrete as compared to conventional concrete M25 grade by testing in three different test methods like compressive strength test, split tensile strength test, and flexural strength test as per IS 10262:1082 code. The materials required for this experimental study are Portland Pozzolana Cement (PPC), coarse aggregate, fine aggregate, polypropylene fiber and jute fiber, water. And to determinate compressive strength test 36 cube specimens of size (150*150*150) mm, spilt tensile strength test 36 cylinder specimens size of (150*300) mm, and flexural strength test 36 beam specimens size of (100*100*500) and all mixes at 7 days, 14 days, and 28 days after casting and curing were tested.

Key words: Polypropylene Fiber, Jute Fiber, Pozzolana Portland Cement, Compressive strength, Split Tensile Strength, Flexural Strength.

I. INTRODUCTION

Concrete is one of the most commonly used materials in the construction industry as its high resistant to compression strength whereas it has low resistant against tensile strength. In the construction sector, the main problem is waste materials during and after constructing each stage of the work of the project. In this investigation, jute fiber and polypropylene fiber are used in concrete of different ratios like; 0.1%, 0.2%, 0.3% for jute fiber and 1%, 2%, and 3% for polypropylene fiber as compare to conventional concrete M25 grade by three different test machines; compressive strength test machine, spilt tensile test machine, and flexural strength test machine as per IS 10262:1082 code. Jute fiber is an environmentally friendly material that is mostly available in India in competitive prices. Also, waste materials of jute fiber have no harm to the environment. Using jute fiber in concrete can decrease the use of polymer fibers which are non-degradable. polypropylene fiber is made by synthetic hydrocarbon polymer. Polypropylene fiber has many benefits than other fibers; durability without corrosion, constructability with light-weight, chemical resistant and increases the compressive strength of the concrete.

II. METHODOLOGY

Jute fiber with cut length (15mm) is shown in figure no 2. Polypropylene fiber with cut length (6mm) shown in figure no 2. PP fiber mixed up with cement and jute fiber then added to coarse aggregate and sand mixture which mixed already. Portland pozzolana cement added as a bending material. Sand (Fineness modulus=4.75mm) and the coarse aggregate used is of 20mm size crushed angular in shape. For this experimental study, the mix design of M25 grade is prepared according to IS 10262:1082. To find the mechanical properties of partial replacement of fine aggregate with polypropylene and jute fiber concrete. Totally forth mixes proportion were made, and the first (M0) was a conventional mix without (Polypropylene and jute fiber). The volume of polypropylene and jute fiber is in different ratios like 0.1%, 0.2%, 0.3%, for jute fiber and 1%, 2% and 3% for polypropylene fiber. All the specimens at 7, 14, and 28 days after casting and curing will be tested in compressive strength testing machine, split tensile strength testing machine and flexural strength testing machine. For this experimental work: compressive strength, split tensile strength, and flexural strength tests were conducted as per IS 10262:1082 code.

2.1. OBJECTIVES OF THE STUDY

For this experimental study, the mix design of M25 grade is prepared according to IS 10262:1082. To find the mechanical properties of partial replacement of fine aggregate with polypropylene and jute fiber concrete. The objectives of the study are to check and study the effect of polypropylene and jute fiber of different ratio like (pp fiber 1%, 2%, 3% & jute fiber 0.1%, 0.2%, 0.3%) using in concrete by testing all the specimens at 7, 14, and 28 days after curing in these three machine tests such as compressive strength machine, split tensile strength machine, and flexural strength machine. Also to compare flexural, tensile and compressive strength of polypropylene and jute fiber concrete with conventional concrete of M25 grade.

Revised Manuscript Received on June 05, 2019

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III. MATERIALS

3.1. Cement: The cement used was Portland pozzolana cement (PPC) of 53 grade shown in Table 1, with a specific gravity 3.15 for the whole work of this excremental study.

Table 1. Physical properties of PPC Cement

Sr.no	Physical properties	PPC
1	Fineness (%)	1
2	IST Minimum (minute)	30
3	FST Maximum (minute)	600 Specified
4	7 days CS MPa	22
5	28 days CS MPa	33
6	Specific Gravity	3.15

3.1.1. Aggregates (Coarse Aggregate and Fine Aggregate)

The coarse aggregate used was of 20mm size crashed angular with a specific gravity 2.65 and water absorption 2.44. Sand used with specific gravity 2.62 and water absorption 2.40, mentioned in Figure no 1. Concrete is made of many components, but is basically made up of materials specified as coarse aggregate. Extensive applications of coarse aggregates originated from the resemblance to standard rock particles, as unlike to fine aggregate, which more closely likes to sand.

Figure no 1. C.A and F.A Aggregates

Coarse Aggregate

Fine Aggregate

3.1.2. Fibers (Polypropylene and Jute Fiber)

polypropylene fiber with 6mm cut length used and its cut length is in Figure no (2), and its physical properties in Table (2). Jute fiber with 15mm cut length added to the mixture and its cut length and physical properties is in Figure no (2) and Table no (3) respectively. In the concrete industry, the applications of fibers increased because of their mechanical properties which improve abilities of concrete like compressive strength, durability, chemical resistant, corrosion-resistant, decreased permeability, being light-weight, increased compatibility, workability, decreased crack era and so on. In this experimental investigation the ratio for polypropylene fiber and jute fiber were added (1%, 2%, and 3%) and (0.1%, 0.2% and 0.3%) respectively.

Figure no 2. PP Fiber and Jute Fiber

Table 2. Physical properties of PP fiber

Sr.no	Properties	Property Value
1	Product	Synthetic polypropylene fiber
2	Polymer	100% virgin PP home-polymer
3	Length	Graded (10 to 20) mm
4	Specific Gravity	0.91
5	Melting Rang	162-164 Co
6	Strength	500-550 N/mm2
7	Diamond Length	10-12 mm
8	Elongation	15-18 %
9	Thickness	35-40µ

Table 3. Physical properties of jute fiber

Sr.no	Parameter	Value/Result
1	Tenacity(g/dn)	3.5-4.5
2	Length	0.2-30 inch
3	Stretch & Elasticity	Not good & 2% elongation at break
4	Specific Gravity	1.48-1.5
5	Abrasion Resistance	Average
6	Color	Yellowish, yellow, brown, golden
7	Dimensional Stability	Good
8	Diameter	18 micron
9	Resiliency	Not good

IV. EXPERIMENTAL DETAILS

In this experiment, the mix design of M25 grade prepared according to IS 10262:2009. To find out the mechanical characteristics of polypropylene and jute fiber replacing with fine aggregate in concrete. The ratio to adding these two fibers were as 1%, 2%, and 3% for pp fiber and 0.1%, 0.2%, and 0.3% for jute fiber and the compositions of the respective ingredients and fibers were mentioned in table no 4.

The number of cubes, cylinders, and beam 36, 36, and 36 was respectively. The size of the moulds of cubes, cylinder and beam were 150×150×150 mm, 150×300 mm and 150×150×700 mm respectively. The method was hand mixing for carrying out mixing and casting the concrete into the specimens, and also for proper mixing the concrete vibration machine was used. Then all the specimens were removed after 24 hours from the time of casting and cured for 7, 14, and 28 days in a water tank. Cubes were tested in Compressive strength testing machine and cylinders and beams were tested in spilt tensile strength testing machine and flexural strength testing machine. The following are the images of specimens. The different steps of the study work in the lab included preparing specimens, weighing and placing sand, gravel, polypropylene and jute fiber for the preparation of concrete mix, casting and curing.

Figure no 3. The images of each stage of casting in the lab

(a) Concrete mixture in the specimens | **(b) specimens**

Table 4. Compositions of the Polypropylene & Jute Fiber Concrete

MIX No	Cement Kg/m³	Water Liter	F.A Kg/m³	C.A Kg/m³
Normal Concrete	425.73	191.58	670.039	1105.73
PJFC 1	425.73	191.58	670.039	1105.73
PJFC 2	425.73	191.58	670.039	1105.73
PJFC 3	425.73	191.58	670.039	1105.73
MIX No	PP Fiber %	PP Fiber Kg/m³	Jute Fiber %	Jute Fiber Kg/m³
Normal Concrete	0	0	0	0
PJFC 1	1	6.7	0.1	0.67
PJFC 2	2	13.4	0.2	1.34
PJFC 3	3	20.1	0.3	2.01

V. RESULTS & DISCUSSION

5.1. Compressive Strength

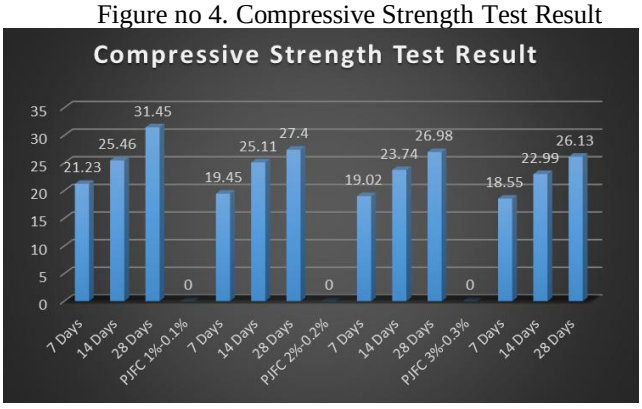
In this step of the experimental investigation, the compressive strength test performed after 7, 14, and 28 days based on the Indian Standard 'Concrete Mix Proportioning' Guideline (First Revision) IS 10262:2009, IS 10262:1082 and the following are the values obtained by compressive strength testing machine that mentioned in table 5. Experimental research displays the high value of 27.04 MPa for PJFC 1 concrete proportion. PJFC 1 it shows that the compressive strength value decreased 9.15% at the age of 7 days, the value at 14 days decreased 1.39%, and at 28 days decreased 16.3% as compared to the result of normal concrete. In PJFC 2 it shows that the value at 7 days decreased by 11.6%, at 14 days decreased by 7.2%, and 16.5% decreased at 28 days. In PJFC 3 it observes that there is a 14.4% reduction at 7 days, 10.7% reduction at 14 days, and 20.4% decrease at 28 days in comparison with normal concrete. However, the value of the target strength for the mix proportioning of M25 grade was 31.60 MPa and the highest value achieved after testing is 27.04 MPa for PJC 1 concrete proportion. So the result can say using and replacing these two different fibers such as polypropylene and jute fiber in concrete cannot be the desired combination.

Table 5. C.S Result of M25 Grade of the Polypropylene Jute Fiber Concrete

Name	Normal Concrete		PJFC 1	PJFC 2	PJFC 3
Materials & Percentage		0%	1%-0.1%	2%-0.2 %	3%-0.3%
Quantity of Ingredients (Kg/m³)	Cement	425.73	425.73	425.73	425.73
	Sand	670.04	662.67	655.3	647.929
	CA	1105.7	1105.7	1105.7	1105.73
	Jute Fiber	0%	0.67	1.34	2.01
	PP Fiber	0%	6.7	13.4	20.1
Compressive Strength (N/mm²)	7 Days	21.23	19.45	19.02	18.55
	14 Days	25.46	25.11	23.74	22.99
	28 Days	31.45	27.04	26.98	26.13

Figure no 4. Showing results for M25 grade of PP & jute fiber concrete for compressive strength.

Figure no 4. Compressive Strength Test Result



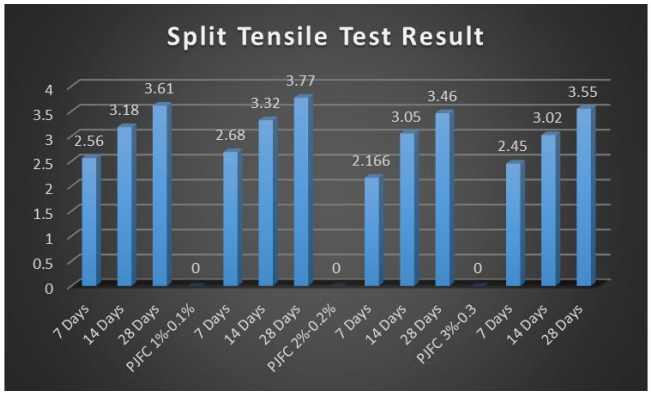
5.2. Split Tensile Strength

To figure out the split tensile strength, Indian Standard 'Concrete Mix Proportioning' Guideline (First Revision) IS 10262:2009, IS 10262:1082 was used. The result of the split tensile strength of the concrete specimens specified after 7, 14, and 28 days according to the mentioned code. The cylinder specimens size of 150 mm×300 mm used according to IS 10262:1082. As table 6 shows, in PJFC 1 it demonstrates a 4.48% increase at the age of 7 days, 4.21% increase at 14 days, and 1.1% increase at 28 days as compared to the results of normal concrete. In PJFC 2 at the age of 7, 14, and 28 days the deduction is 18.5%, 4.26%, and 4.33% respectively. In PJFC 3 it shows that a 4.5% decrease at the age of 7 days, a 5.3% decrease at 14 days, and a 1.6% decrease at 28 days. All the cylinder specimens were compared with the result of normal concrete. The highest value of the spilt tensile strength test is PJC1 3.77 N/mm² at 28 days. The figure no 5. displaying the results for M25 grade of PJFC for split tensile strength.

Table 6. S.T.S Result of M25 Grade of the Polypropylene Jute Fiber Concrete

Name		Normal Concrete	PJFC 1	PJFC 2	PJFC 3
Materials & Percentage		0%	1%-0.1%	2%-0.2%	3%-0.3%
Quantity of Ingredients (Kg/m³)	Cement	425.73	425.73	425.73	425.73
	Sand	670.04	662.67	655.3	647.929
	CA	1105.7	1105.7	1105.7	1105.73
	Jute Fiber	0%	0.67	1.34	2.01
	PP Fiber	0%	6.7	13.4	20.1
Compressive Strength (N/mm²)	7 Days	2.56	2.68	2.16	2.45
	14 Days	3.18	3.32	3.05	3.02
	28 Days	3.61	3.77	3.46	3.55

Figure no 5. Split Tensile Strength Result



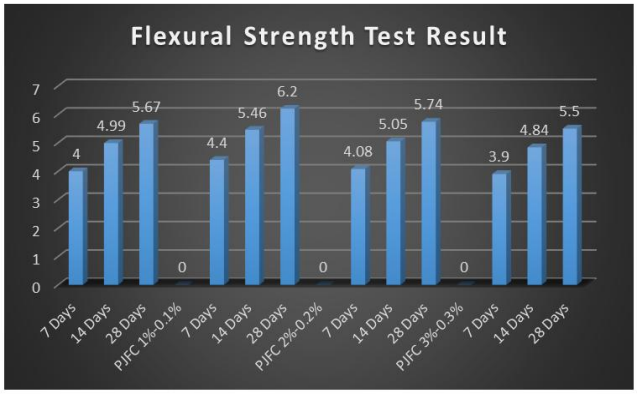
5.3. Flexural Strength

The flexural strength test performed by testing a two-point load of the beam after casting and curing at 7, 14, and 28 days according to IS 10262:1082 code in the flexural strength testing machine. The beam specimens size of 150mm×150mm×700mm was used based on the mentioned code. Based on the data obtained which are written in Table 7, for the result of normal concrete the value determined at 7, 14, 28 days are 4 N/mm², 4.99 N/mm², and 5.67 N/mm² independently. In PJC 1 it shows that 9% increased at 7 days, 8.6% increased at 14 days, and 8.5% increased at the age of 28 days. But in PJC 2 observed that increased percentage are 1.9%, 1,2%, and 1% for 7, 14, 28 days individually which are less than PJC 1 values. In oppose, in PJC 3 the flexural strength result shows deduction 2.5%, 3%, and 3% for 7, 14, 28 days separately. The figures no 6. showing the results for M25 grade of PJFC for flexural strength.

Table 7. F.S Result of M25 Grade of the Polypropylene Jute Fiber Concrete

Name		Normal Concrete	PJFC 1	PJFC 2	PJFC 3
Materials & Percentage		0%	1%-0.1%	2%-0.2%	3%-0.3%
Quantity of Ingredients (Kg/m³)	Cement	425.73	425.73	425.73	425.73
	Sand	670.04	662.67	655.3	647.929
	CA	1105.7	1105.7	1105.7	1105.73
	Jute Fiber	0%	0.67	1.34	2.01
	PP Fiber	0%	6.7	13.4	20.1
Compressive Strength (N/mm²)	7 Days	21.23	19.45	19.02	18.55
	14 Days	25.46	25.11	23.74	22.99
	28 Days	31.45	27.04	26.98	26.13

Figure no 6. Flexural Strength Test Result



VI. CONCLUSION

- It is hereby concluded that by adding polypropylene and jute fiber the compressive strength for PJC1, PJC2, and PJC3 at 28 days' decreases to 16.3%, 16.5%, and 20.4% respectively.
- It shows that the split tensile strength for PJC1 increases by 1.1% whereas for PJC2 and PJC3 decreases to 4.33% and 1.6% separately.
- It is observed that the flexural strength for PJC1 and PJC2 increases to 8.5%, and 1%, respectively. But in PJC3 the flexural strength decreases to 3%.
- Due to the addition of adding polypropylene and jute fiber, there is a significant decrease in the compressive strength of the concrete cube and the split tensile strength of the concrete cylinder as compared to normal concrete. Whereas by adding 1% - 0.1% of PP fiber and jute fiber (PJC1) in the concrete admixture, the flexural strength increases.
- Based on the results of this study, using two different fibers as PP fiber and jute fiber in concrete, it seems that more investigations are needed to find a proper combination.

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