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Comparative strength of Natural, Artificial, and Combination fibre reinforced concrete

Mr. Nilraj Y.Patne[1]
UG Scholars
Department of Civil Engineering
D.Y. Patil College of Engineering,
Akurdi, Pune-44,

Ms. Bhagyashree B. Bagul[2]
Department of Civil Engineering
D.Y. Patil College of Engineering,
Akurdi, Pune-44,

Ms. Dhanashri S. Bhosale[3]
Department of Civil Engineering
D.Y. Patil College of Engineering,
Akurdi, Pune-44,

Mrs. Ashwini R.Patil [4]
Asst Prof.
Department of Civil Engineering
D.Y. Patil College of Engineering,
Akurdi, Pune-44,

***Abstract*— Fibre Reinforced concrete (FRC) is a combination of concrete and randomly distributed discrete fibres. Use of fibres in concrete enhances its mechanical properties. Fibres are basically distinguished on basis of its origin. Various papers have been published before on use of natural and artificial fibres in concrete. An experimental study is carried to analyze the strength of concrete by using fibres from different origin. Fibrous material like bagasse, coconut coir etc are in abundant around us. We are unaware of fact that these materials can be used in concrete to enhance its properties. So we decided to use bagasse as our natural fibre due its easy availability. Also we have used polypropylene as artificial fibre. We further experimented with combination of both natural and artificial fibres. Our basic aim was to increase compressive strength of concrete and to make it more crack resistant. The properties studied include compressive strength and workability. The studies have been conducted as per recommended procedures of relevant IS codes on M40 mix. Fractions of 0.5%, 1.0% and 1.5% of fibres by weight of cement have been used for comparative study of compressive strength of concrete and results are obtained.**

Keywords: Reinforced Concrtete, Compressive Strength; Bagasse; Polypropylene.

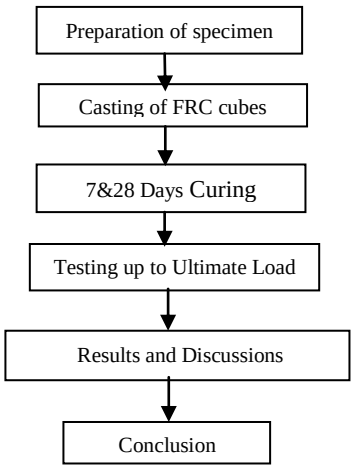
I. INTRODUCTION

Concrete has been most widely used as construction material for over 100years, it is good in compression. But plain concrete inherently weak in tension and has limited ductility and little resistance to cracking. This deficiency prevents its use as building material. These deficiencies have led researchers to investigate use of fibre in concreting i.e. Fibre Reinforced Concrete (FRC).Fibre reinforced concrete is concrete containing fibrous material which increases its structural integrity. Fibres are used in concrete to control cracking due to plastic shrinkage and drying shrinkage. According to research done before, it has been found that, the addition of fibres increases its compressive strength and reduces cracks and make it more durable.

This is an experimental investigation to study the compressive strength of fibre added concrete cubes of grade M-40 and compared against conventional concrete. Natural fibres like rice husk, coconut coir, and bagasse are used nowadays in concrete as natural fibre to improve its strength.

Bagasse is fibrous material that remains after extraction of juice from sugarcane. It is generally use as bio-fuel or mostly it is treated as waste material. So we made an attempt to use it as construction material in our project. We have used polypropylene for our artificial fibre. Polypropylene posses good ductility. It is light weight in nature, it is lighter than water and 34% lighter than polyester and 20 % lighter than Nylon. Hence serves basic purpose of our investigation. Our crucial part of study was to check the results of combination of natural and artificial fibres. An attempt has been made to combine both properties of natural and artificial fibres so as to obtain a better result from concrete. As we know natural fibres are easily available and have relatively low cost where as artificial fibre i.e. polypropylene has specific gravity 0.90-0.91gm/cm3 because of its low specific gravity polypropylene yields the greatest volume of fibre for given weight. In our experiment we added to 50-50 of both natural and artificial fibre.

II. METHODOLOGY



A. Casting Procedure of all blocks

The constituent materials of concrete we used are cement, sand, and aggregate. As per IS code 516.1959 testing on this materials were carried out. Concrete of M40 grade was designed as per IS code recommendations. Cubes were cast of

Size of 150mm x 150mm x 150mm. Concrete was placed uniformly in mould in three layers with proper compaction. Removal of cubes from mould was done after 24 hours and specimens were kept for curing 7 and 28 days. As per mix design 3 cubes were casted for per fraction of 0.5%, 1.0%, 1.5%. We have casted 9 cubes per fibre i.e. Natural (bagasse), Artificial (polypropylene) and combination of both. We also have casted 3 cubes of conventional concrete for comparative study.

Fig. 1 *casting of cubes*

III. RAW MATERIAL

A) Materials used

1) *Cement:* Ordinary Portland cement (OPC) of 53 grade of Birla Super Cement is used in this experimental work.

TABLE I
PROPERTIES OF CEMENT

Sr. No.	**Properties of cement**	**Results**
1.	Specific Gravity	3.15
2.	Standard consistency	29.50
3.	Fineness	294 m^2/kg
4.	Initial setting time	155 min
5.	Final setting time	235 min

2) *Sand:* Artificial crushed sand is used. The properties of sand are as shown in following table:

TABLE II
PROPERTIES OF CRUSHED SAND

Sr. No.	Properties of crushed sand	Results
1.	Specific Gravity	2.72
2.	Bulkage	NA
3.	Fineness modulus	3.38
4.	Water absorption	3.83%

3) *Coarse aggregate:* It consists of 10 mm and 20 mm crushed granite aggregate. Sieve analysis is also carried out on aggregate. The properties are shown in following tables

TABLE III
PROPERTIES OF COURSE AGGREGATE
(10 MM)

Sr. No.	Properties of 10mm coarse aggregate	Results
1.	Specific Gravity	2.92
2.	Fineness modulus	6.28
3.	Water absorption	0.89%
4.	Crushing value	13.49%
5.	Impact value	9.72%
6.	Flakiness Index	7%
7.	Elongation Index	16%

TABLE IV
PROPERTIES OF COURSE AGGREGATE (20MM)

Sr. No.	Properties of 20mm coarse aggregate	Results
1.	Specific Gravity	2.94
2.	Fineness modulus	7.04
3.	Water absorption	0.94%
4.	Crushing value	14.68%
5.	Impact value	7.2%
6.	Flakiness Index	6%
7.	Elongation Index	10%

Results of sieve analysis for 10 mm aggregate are as follows:

TABLE V
SIEVE ANALYSIS REPORT (10MM)

IS Sieve size (mm)	% passing (20mm)	Remark
20	96	Conforming to IS 383 : 1970, Table - 2
10	43	
4.75	3	

TABLE VI
SIEVE ANALYSIS REPORT (20MM)

IS Sieve size (mm)	% passing (10mm)	Remark
10	100	Conforming to IS 383: 1970, Table – 4, Zone II.
4.75	99.10	
2.36	86.30	
1.18	75.20	
0.6	37.60	
0.3	13.10	
0.15	7.90	
below	0	

4) Water: Clean, potable water is used for mixing the concrete and for curing.

Fig 2 *samples of bagasse and polypropylene*

B) *Concrete Mix Design*

Design concrete mix of M40 grade is used in experimental work. The detail of mix proportion is shown in below table. All cubes are casted with conventional procedure.

TABLE VII
MIX PROPORTION FOR 1M3

Mix grade	Water (kg)	Cement (kg)	Crushed sand (kg)	10mm aggregate (kg)	20mm aggregate (kg)
M40	195.63	430	803	547	591

IV) TEST RESULTS

A) Slump cone test

Slump cone test is carried out on fresh concrete. Workability of fibre reinforced concrete is found out by this test. The results of representative sample from each trial mix is shown in table no. VIII

TABLE VIII
RESULTS OF SLUMP CONE TEST

Trial Mix No.	Slump Cone (mm)	Trial Mix	Slump Value (mm)
TM1	30	TM6	50
TM2	40	TM7	50
TM3	30	TM8	30
TM4	35	TM9	40
TM5	50	TM10	30

B) Compressive strength

Concrete specimens of plain and fibre reinforced concrete are tested for 7 and 28 days curing. The test results obtained are given in table no IX. Change in compressive strength after addition of fibres is expressed in percentage.

TABLE IX
COMPRESSIVE STRENGTH AT 7 DAYS
(BAGASSE FIBRES)

Trial Mix No.	Fibre	Fraction (%)	Avg. compressive strength at 7 days (N/mm^2)	Change in compressive strength (%)
TM1	Conventional	0	33.920	0
TM2	Bagasse	0.5	35.403	4.37
TM3		1.0	28.880	-14.85
TM4		1.5	32.140	-5.24

TABLE X
COMPRESSIVE STRENGTH AT 7 DAYS
(POLYPROPYLENE FIBRES)

Trial Mix No.	fibre	Fraction (%)	Avg. compressive strength at 7 days (N/mm^2)	Change in compressive strength (%)
TM5	Polypropylene	0.5	32.62	-3.83
TM6		1.0	36.88	8.73
TM7		1.5	28.89	-14.82

TABLE XI
COMPRESSIVE STRENGTH AT 7 DAYS
(BAGASSE AND POLYPROPYLENE FIBRES)

Trial Mix No.	fibre	Fraction (%)	Avg. compressive strength at 7 days (N/mm^2)	Change in compressive strength (%)
TM8	Combination of Bagasse and Polypropylene	0.5	45.35	33.69
TM9		1.0	37.04	9.19
TM10		1.5	36.15	6.57

Compressive test results afterv28 days are shown in following table.

TABLE XII
COMPRESSIVE STRENGTH AT 28 DAYS
(BAGASSE FIBRES)

Trial Mix No.	fibre	Fraction (%)	Avg. compressive strength at 28 days (N/mm^2)	Change in compressive strength (%)
TM1	Conventional	0	55.55	0
TM2	Bagasse	0.5	58.95	6.12
TM3		1.0	57.03	2.66
TM4		1.5	56.74	2.14

TABLE XII
COMPRESSIVE STRENGTH AT 28 DAYS
(POLYPROPYLENE FIBRES)

Trial Mix No.	fibre	Fraction (%)	Avg. compressive strength at 28 days (N/mm^2)	Change in compressive strength (%)
TM5	Polypropylene	0.5	54.52	-1.85
TM6		1.0	57.33	3.20
TM7		1.5	51.93	-6.51

TABLE XII
COMPRESSIVE STRENGTH AT 7 DAYS
(BAGASSE AND POLYPROPYLENE FIBRES)

Trial Mix No.	fibre	Fraction (%)	Avg. compressive strength at 28 days (N/mm^2)	Change in compressive strength (%)
TM8	Combination of Bagasse and Polypropylene	0.5	66.22	12.00
TM9		1.0	62.81	13.06
TM10		1.5	57.78	4.01

Below graphs show the graphical representation of change in compressive strength after addition of fibres. Various trial mixes are shown on X-axis and compressive strength in N/mm^2 is shown on Y- axis.

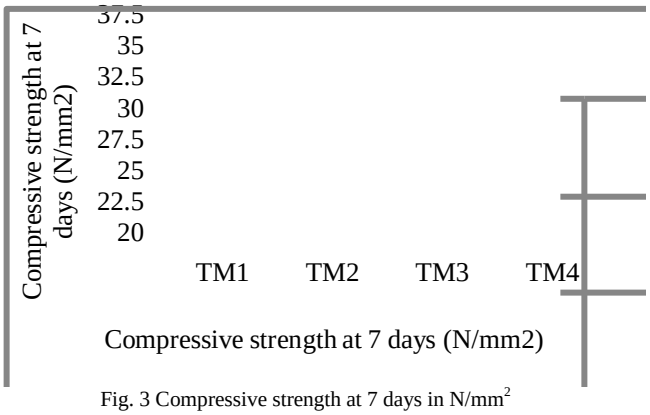


Fig. 3 Compressive strength at 7 days in N/mm^2

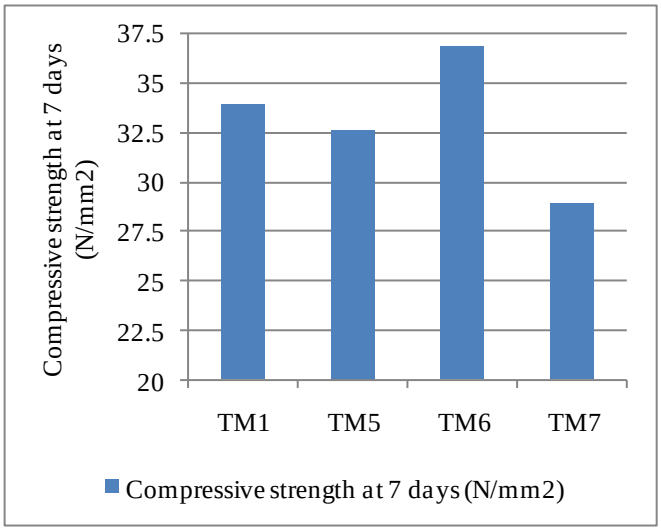


Fig. 4 Compressive strength at 7 days in N/mm^2

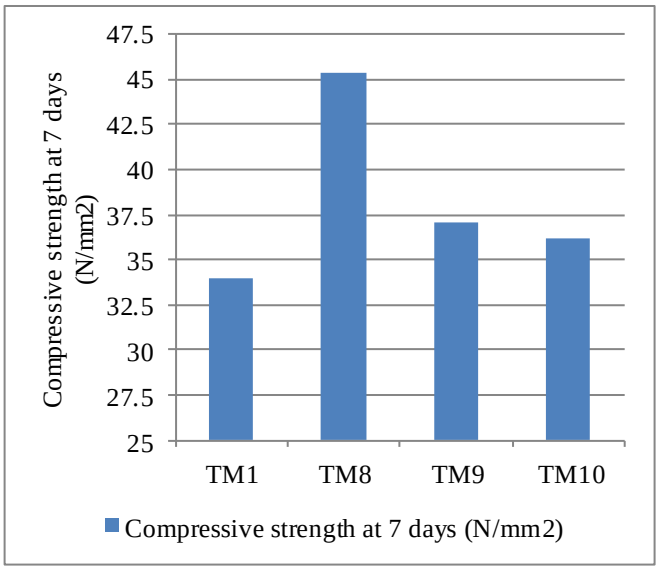


Fig. 5 Compressive strength at 7 days in N/mm^2

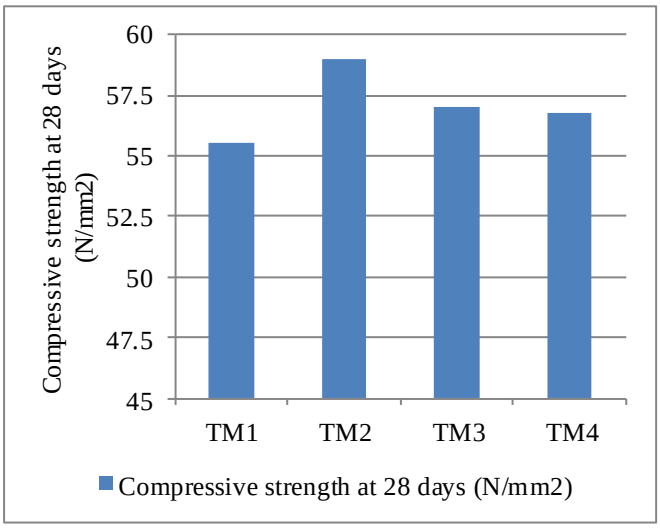


Fig.6 Compressive strength at 28 days in N/mm^2

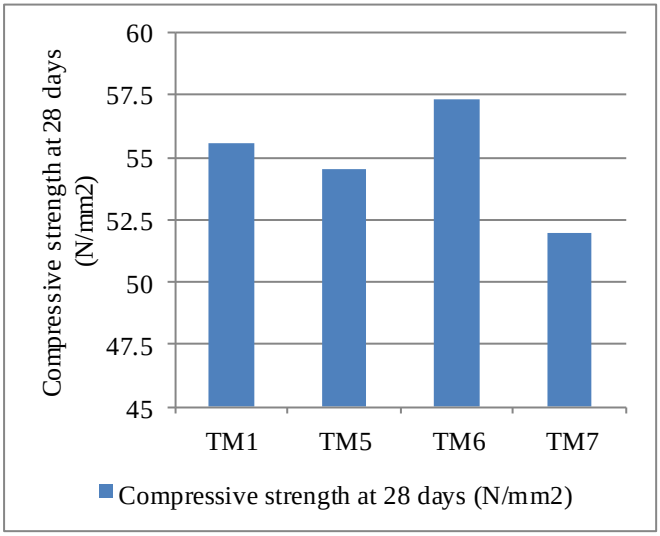


Fig. 7 Compressive strength at 28 days in N/mm^2

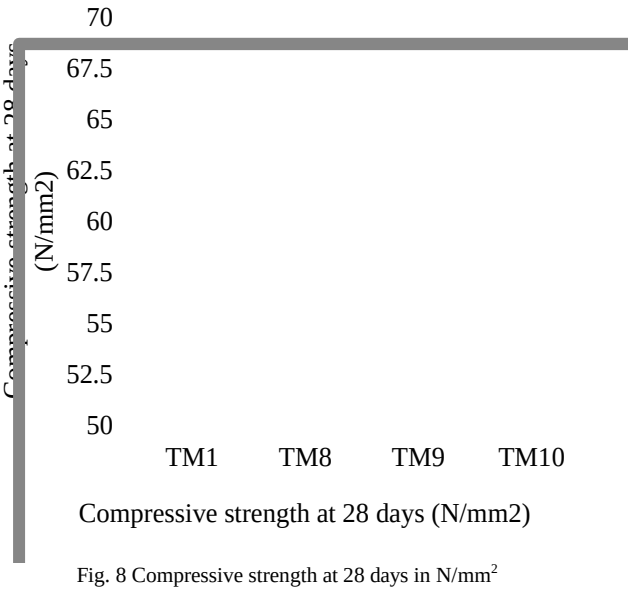


Fig. 8 Compressive strength at 28 days in N/mm^2

Fig. 9 Visible cracks on cube after testing

V) CONCLUSION

Based on the test results and discussions above, the following conclusions can be drawn:

- Addition of fibre increases the compressive strength of concrete with respect to the conventional concrete.
- Addition of 0.5% bagasse fibre increases the compressive strength in 7 days to by 4.37%.
- Addition of 1.0% polypropylene fibre increases the compressive strength in 7 days by 8.72%.
- Addition of 0.5% combination of bagasse and polypropylene fibre increases the compressive strength in 7 days by 33.69%.
- Addition of 0.5% of bagasse fibre increases the compressive strength in 28 days by 6.12%.
- Addition of 1.0% polypropylene fibre increases the compressive strength in 28 days by 3.20%.
- Addition of 0.5% combination of bagasse and polypropylene fibre increases the compressive strength in 28 days by 19.20%.
- Ultimately it is obtained that combination of bagasse and polypropylene fibres increases the compressive strength of concrete.
- Use of combination of natural and artificial fibres reduces crack development in concrete structures.

VI) REFERANCES

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