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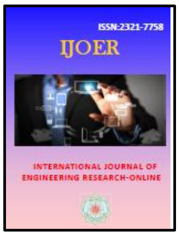
EXPERIMENTAL INVESTIGATION ON SYNTHETIC FIBER REINFORCED CONCRETE PAVEMENTS

V.PRASHANTHA REDDY[1], Dr. RAJA SEKHAR[2], C.VIDYA SAGAR[3] ,K.ASHALATHA[4], S.PADMAJA[5]

[1]M.Tech, Student, Department of structural Engineering, Siddhartha Institute of Technology, Tirupati, India
Email:vprashanth920@gmail.com
[2] Professor, Department of structural Engineering, Siddhartha Institute of Technology, Tirupati, India,
[3] Assistant Professor, Department of Civil Engineering, Priyadarshini Institute of Technology and Sciences, Tirupati, India
[4] Lecturer, Department of Civil Engineering, srikalahasteeswara Institute of Technology, Srikalahasti, India
[5]Assistant Professor, Department of Civil Engineering, Vemu Institute of Technology and Sciences, Tirupati, India India.email: sagar.cvsr@gmail.com



ABSTRACT

If properly designed, constructed and maintained, reinforced or pre-stressed concrete structures are generally very durable. However, for structures in aggressive environment, corrosion of steel can be significant problem. Shrinkage cracking of concrete is a major problem in plain cement concrete pavements especially in tropical regions. Examples of structures that may be particularly at risk include marine structures, bridges subjected to de-icing salts and industrial buildings. In the last decade, there has been a considerable increase in interest in the use of non-metallic reinforcement to cope with this corrosion problem at many institution, advanced composite reinforcing materials have been developed, typically consisting of align continuous fibers embedded in resin and shaped to form beams and slabs, grid shape structures.

To overcome corrosion and shrinkage cracking of plain concrete, sometimes the addition of synthetic fiber to the concrete mix is suggested. Synthetic fibers used in our study are Polypropylene and Polyester. Recron'3s Fibers are engineered micro fibers with a unique "Triangular" Cross-section, used as secondary reinforcement of Concrete. It complements Structural Steel in enhancing Concrete's resistance to shrinkage cracking and improves mechanical properties such as Flexural / Split Tensile and transverse Strengths of Concrete along with the desired improvement in Abrasion and Impact Strengths.

Six concrete mixes with fiber dosages 0.1%, 0.2% and 0.3% by volume fraction besides the control concrete mix were manufactured. In this work, the results of strength properties of synthetic fiber reinforced concrete are presented. Also conducted the conventional tests for concrete such as the compressive strength and flexural strength of concrete samples are made with different amounts.

Compressive strength test and flexural strength test was conducted on the cubical and beam specimens respectively for all the mixes at different curing periods as per IS 516 (1991). The cubes of size 150 mm x 150 x 150 mm were cast and tested for compressive strength. The beams of size 500 mm x 100 x 100 mm were cast and tested for flexural strength.

1. INTRODUCTION

Plain concrete has a low tensile strength, little imperviousness and limited ductility to cracking. Interior miniaturized scale cracks are naturally exhibit in the concrete and its poor strength is because of the propagation of such micro cracks, eventually leading to brittle crack of the concrete. In plain concrete and similar brittle materials, micro cracks grow even before loading, especially because of drying shrinkage or different reasons for volume change. The width of these introductory cracks from time to time exceeds a few microns; however their other two measurements may be of higher magnitude. At the point when loaded, the micro cracks out proliferate and up, and inferable from the impact of stress concentration, additional cracks frame in places of minor deformities. The structural cracks continue gradually or by tiny jumps because they are retarded by different obstacles, change of direction in bypassing the more safe grains in matrix. The improvement of such small scale cracks is the main cause of inelastic deformations in concrete. It has been recognized that the addition of little, closely spaced and uniformly dispersed fibers to concrete would go about as crack arrester and would considerably enhance its static and dynamic properties. This kind of concrete is known as **"Fiber Reinforced Concrete"** FRC is cement- based compound material that has been developed in recent years. It has been effectively used in construction with its excellent flexural-tensile strength, resistance to spitting, impact resistance and excellent permeability and frost resistance. It is a successful way to increase toughness, shock resistance and resistance to plastic shrinkage cracking of the mortar. At present, different materials like glass, steel, nylon, polypropylene, carbon and different characteristic materials like coconut and horsehair are being utilized in concrete to make FRCs .The most famous among these are the steel fibers, trailed by polypropylene, glass, nylon and carbon (Stevens,1995; Banthia, 2012). As per American Concrete Institute, steel strands meant for concrete reinforcement are short, discrete lengths of steel of any cross section having an aspect ratio of 20- 100 (ACI, 1996).

Steel fiber reinforced concrete frequently contracted as SFRC shows vastly improved execution than the same concrete with no fiber. It's compressive, flexural and tensile strengths are much higher (Banthia, 2012). That is the reason SFRC is every now and again being utilized as a part of slabs subjected to high traffic loads. Aside from steel strands, various specialists from everywhere throughout the world have also worked on other fiber-reinforced concretes and have recommended that mechanical properties of fiber reinforced concrete are much predominant than the conventional concrete (Zahra et al. 2014 and Song et al. 2005). They have reported that the weakness and the low tensile strength connected with a conventional concrete can be overcome by including fibers (Vikrant at al., 2012).

2. EXPERIMENTAL INVESTIGATION:

2.1 MATERIALS:

CEMENT :Cement is considered to be the best binding material and at present, no construction work can be taken up without cement. As a rule, normal cement takes after in numerous regards to famously water driven lime in building properties. The product got by burning and crushing to powder, a close mixture of proportional calcareous and argillaceous material is called cement. It is usually manufactured from limestone mixed with shale, clay. Properly proportioned raw materials are pulverized into kilns where they are heated to a temperature of 1300 to 1500˚C. The clinker is cooled and ground to fine powder with addition of about 3 to 5% of gypsum. The OPC (53 grade) used in the present work is of Zuari cement.

Ordinary Portland Cement (OPC) is one of several types of cement being manufactured throughout the world, are some of the more commonly used. OPC is the general purpose cement used in concrete constructions. OPC is a compound of lime (Cao), silica (SiO_2), alumina (AL_2O_3), iron (Fe_2O_3) and sulphur trioxide (SO_3), Magnesium (Mgo) is present in small quantities as an impurity associated with limestone.

AGGREGATES: Good quality of river sand was usedas the fine aggregate conformed to sand of Zone: II, having a specific gravity of 2.65. Locally available crushed angular material maximum size of coarse aggregate 20mm and it passing through 22.5mm and retained on 20mm sieve. The coarse aggregate having specific Gravity as 2.82**,** Fineness modulus as 7.68and water adsorption as 3.65.

COARSE AGGREGATE (CA): Aggregates which retain on 4.75 mm sieve Grading of CA is supplied in nominal sizes. Granite, angular crushed of maximum size 20 mm conforming to IS: 383:1970 is utilized. Proportions of different sizes are determined as per IS: 2386:1986

FINE AGGREGATE: Aggregates passing 4.75 mm sieve. Fines are graded into zones in light of their fineness. Based on percentage passing through 600 micron sifter gives the zone of the aggregate.River sand is utilized.

SYNTHETIC FIBERS: Synthetic fibers utilized as a part of our study are Polypropylene and Polyester. Recron'3s Fibers are engineered micro fibers with a special "Triangular" Cross-section, utilized as secondary reinforcement of Concrete. It supplements Structural Steel in improving Concrete's imperviousness to shrinkage cracking and enhances mechanical properties, for example, Flexural/ Split Tensile and transverse Strengths of Concrete alongside the desired improvement in Abrasion and Impact Strengths. Recron;3s Fibers are manufactured in an ISO 9001:2000 facility for utilization in Concrete as a "Secondary Reinforcement" at a rate of dosage varying from 0.1% to 0.4% by volume of concrete (0.9kgs m^3-3.60kgs m^3).

ADMIXTURE (VARAPLAST 123):

VARAPLAST 123 is used as admixture in this study; it acts as water reducing agent and high performance in concrete. VARAPLAST 123 (BS 5075 – 1982and ASTM C494 Type G. IS 9103 -1999) is a chloride free, super plasticizing admixture in view of chose manufactured polymers. It is supplied as brown solutions which is immediately dispersible in water. VARAPLAST 123 can give abnormal state of water reduction and hence major increase in strength can be acquired coupled with good retention of workability during placement. The properties of admixture is given in table

Water: Tap water has been used to mix the ingredients of concrete in this study. Water is an important ingredient of concrete, which not only actively participates in the hydration of cement but also contributes to the workability of fresh concrete. The water is needed for preparation of mortar, blending of cement concrete and for curing work and so during construction work. The quality and amount of water has much impact on the quality of mortar and cement concrete in construction work.

Mix proportions: The M45 mix proportion of cement, fine aggregate and coarse aggregate as 1**:** 1.76: 2.85.Table-1 shows the Mix proportion for M45 grade concrete

2.2 Preparation and curing of test specimens

From each concrete mix, 150mmx150mmx150mm cube specimens are prepared for the testing of compressive strength, 500mmx100mmx100mm beam specimens are prepared for the testing of flexural strength were cast from concrete mixes containing with fibers and without fibers. These specimens are de molded after 24 hours and marked for identification and kept specimens are cured in water at

temperature 270c±20ctill the age of testing.

Table-1 :Mix proportion for M45 grade concrete

Material	Quantity	Proportion
Cement	410kg/m^3	1
Fine aggregate	725kg/m^3	1.76
Coarse aggregate	1170kg/m^3	2.85
water	160kg/m^3	0.39
Fibers	0.1%-0.4% by volume	-
Admixtures	0.5-0.8% of weight of cement	-
Slump	60-100mm	-
CalciumChlorie Content	Nil	
Specific Gravity	1.22 at 25° C	
Air Entrainment	Less than 1% extra air entrained	
Setting Time	No impediment at ordinary measurements.	
ChlorideContent	Nil to BS 5075.	
Cement Compatibility	Compatible with sulfate opposing and other Portland bonds, high alumina concretes and bond substitution materials, for example, PFA, GGBFS and Small scale silica.	

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Toughness	Water decrease gives increment in thickness and water impermeability which enhances toughness

Experimental methodology

3.1Properties of Fresh concrete mix: In this experimental study to determine the properties of fresh concrete mix is workability. Shape and size of moulds, amount and condition of reinforcement, the properties of fresh concrete are impact factors.

3.2 Tests on hardened concrete: In this study to determine the mechanical properties of fiber reinforced and conventional concrete using non-metallic and metallic fibers under compression and flexural strength , for polypropylene and polyester fibers, 0.1 to 0.4% by volume. The tests for compressive strength on cubes were measured at 7, 14 and 28 days curing as pet IS: 516-2000, and test for flexural strength on beams were measured at 7, 14 and 28 days of curing as per IS: 516-2000.

3.2.1 Compressive strength: The strength of concrete is usually determined by the crushing Out of many tests connected to the concrete; this is the most extreme important which gives an idea about all the attributes of concrete. By this single test one judge that whether Concreting has been done properly or not. For cube test two types of samples either cubes of 150mm x 150mm x 150mm or 100mm x 100mm x 100 mm depending on the size of aggregate are utilized. For most of the cubical molds of size 150mmx150mmx150mm are normally utilized.

This concrete is poured in the mold and tempered properly so as not to have any voids. Following 24 hours these molds are removed and test samples are placed in water for curing. The top surface of these samples should to be made even and smooth. This is done by putting cement paste and spreading smoothly on entire area of sample

The cubes were tested on their sides without packing between the cube and the steel plates of the testing machine. One of the plates is carried on a base and is self-adjusting and the load was steadily and uniformly applied, beginning from zero at the rate of 350 kg/cm^2 per minute.

Flexural Strength Test : Flexural strength test was led on the samples for all the mixes at different curing periods according to IS 516 (1991). Three concrete beam samples of size 500 mm x 100 mm x 100 mm were casted and tested for each age and each mix. The load was applied gradually till the failure of the sample occurs. The maximum load applied was then noted. The distance between the line of crack and the close support "a" was measured. The flexural strength (f_{cr}) was ascertained as takes after: At the point when "a" is greater than 13.3 cm for 10 cm example, f_{cr} is $f_{cr} = (P \times l)/ (b \times d^2)$

At the point when "a" is less than 13.3 cm yet more noteworthy than 11.0 cm for 10 cm sample, f_{cr} is $f_{cr} = (3 \times P \times a)/ (b \times d^2)$.

Steel mould of dimension 150mm x 100mm x 100mm used for casting of concrete beams filled with polypropylene, 0.1 to 0.4% by volume of concrete and polyester, 0.1to 0.4% by volume of concrete. The specimens were casted and tested to determine the average flexural strength at a curing period of 7, 14 and 28 days.

RESULTS AND DISCUSSION

The result of the present investigation is presented both in tabular and graphical forms. The interpretation of the results is based on the current knowledge available in the literature as well as on the nature of results obtained. These chapters present the experimental results and discuss specific gravity and sieve analysis of both fine aggregate and coarse aggregate and compressive and flexural strength of different proportions of polypropylene and polyester fibers.

The test results of compressive strength for 7 days, 14 days& 28 days are given in Table 2,3,4 and fig 1,2,3 for 0.1,0.2,0.3% (by volume of concrete) of control sample, polypropylene fibers and polyester fiber.

The test results of flexural strength for 7 days, 14 days & 28 days are given in Table 5,6,7 and fig 4,5,6 for 0.1,0.2,0.3% (by volume of concrete) of control sample, polypropylene fibers and polyester fiber.

Variation of compressive strength:

Table 2: Compressive Strengths results of concrete cubes at 0.1% (by volume of concrete) of control sample, polypropylene fibers and polyester fiber:

S.No	Type of Sample	Compressive Strength (N/mm^2)		
		7Days	14Days	28Days
1	Control sample with out fiber	33.82	46.75	52.17
2	Concretewith polypropalane fiber	36.7	42.8	55.5
3	Concrete with polyester fiber	34.5	43.25	54.15

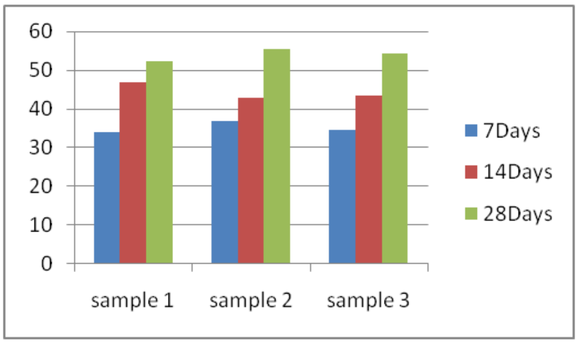

Fig 1: Compressive Strengths results of concrete cubes at 0.1% (by volume of concrete) of control sample polypropylene fibers and polyester fiber

Table 3: Compressive Strengths results of concrete cubes at 0.2% (by volume of concrete) of control sample polypropylene fibers and polyester fiber

S.No	Type of Sample	Compressive Strength (N/mm^2)		
		7Days	14Days	28Days
1	Control sample with out fiber	33.82	46.75	52.17
2	Concretewith polypropalane fiber	35.00	48.50	57.50
3	Concrete with polyester fiber	34.50	47.15	55.05

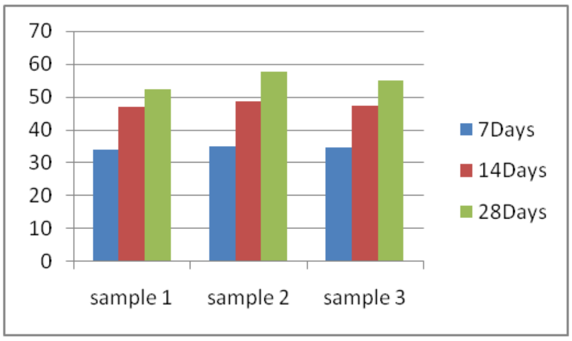

Fig 2: Compressive Strengths results of concrete cubes at 0.1% (by volume of concrete) of control sample polypropylene fibers and polyester fiber:

Table 4: Compressive Strengths results of concrete cubes at 0.3% (by volume of concrete) of control sample polypropylene fibers and polyester fiber

S.No	**Type of Sample**	**Compressive Strength (N/mm^2)**		
		7Days	**14Days**	**28Days**
1	Control sample with out fiber	33.82	46.75	52.17
2	Concretewith polypropalane	36.4	50.25	60.5
3	Concrete with polyester fiber	36.05	48.05	57.03

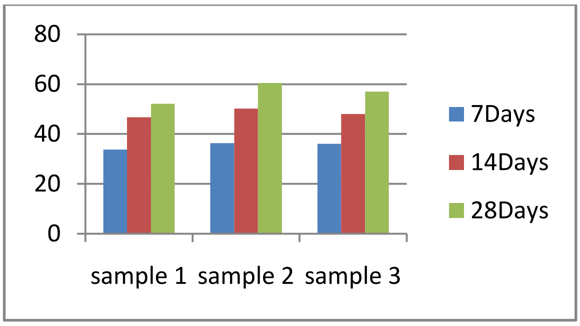

Fig 3: Compressive Strengths results of concrete cubes at 0.1% (by volume of concrete) of control sample polypropylene fibers and polyester fiber

Variation of flexural strength:

The different beams are casted and tests were led on the beams after standard curing and results are as per the following

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Table 5: Flexural Strengths results of concrete beams at 0.1% (by volume of concrete) of control sample polypropylene fibers and polyester fiber

S.No	Type of Sample	Compressive Strength (N/mm^2)		
		7Days	14Days	28Days
1	Control sample with out fiber	3	5.2	6.6
2	Concretewith polypropalane fiber	4.1	5.5	6.9
3	Concrete with polyester fiber	4	5.3	6.1

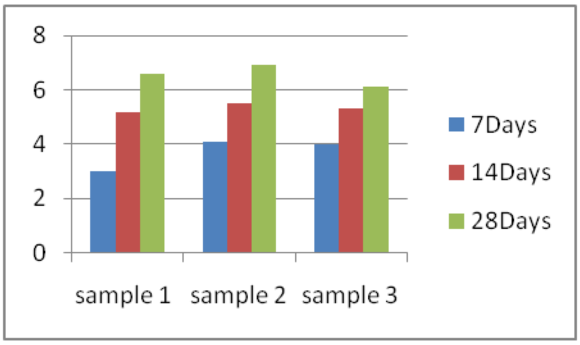

Fig 4: Flexural Strengths results of concrete beams at 0.1% (by volume of concrete) of control sample polypropylene fibers and polyester fiber.

Table 6: Flexural Strengths results of concrete beams at 0.2% (by volume of concrete) of control sample polypropylene fibers and polyester fiber:

S.No	Type of Sample	Compressive Strength (N/mm^2)		
		7Days	14Days	28Days
1	Control sample with out fiber	3	5.2	6.6
2	Concretewith polypropalane fiber	4.3	5.6	6.5
3	Concrete with polyester fiber	4.2	5.2	6

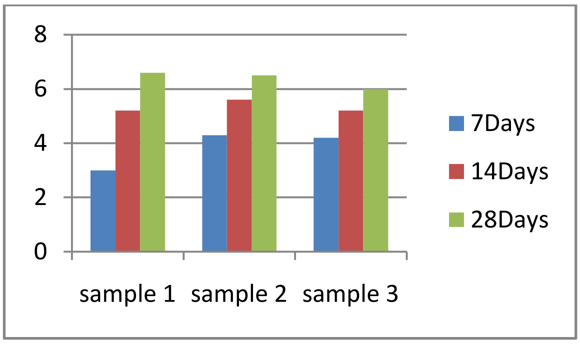

Fig 5: Flexural Strengths results of concrete beams at 0.1% (by volume of concrete) of control sample polypropylene fibers and polyester fiber.

Table 6: Flexural Strengths results of concrete beams at 0.3% (by volume of concrete) of control sample polypropylene fibers and polyester fiber

S.No	Type of Sample	Compressive Strength (N/mm^2)		
		7Days	14Days	28Days
1	Control sample with out fiber	3	5.2	6.6
2	Concretewith polypropalane fiber	4.3	5.2	6.4
3	Concrete with polyester fiber	4.4	4.9	6

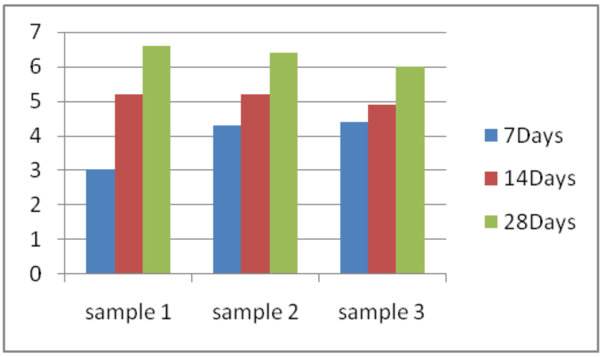

Fig 6: Flexural Strengths results of concrete beams at 0.1% (by volume of concrete) of control sample polypropylene fibers and polyester fiber.

CONCLUSION:

Conclusions From the experimental work, the major conclusions are given below. .

- Fiber reinforced concrete utilization in pavements reduces the maintenance cost by reducing the overall lifecycle cost though it has high initial cost.

- The inclusion of fibers is more advantage in case of pavements by reducing the crack formation and also giving additional early compressive strength to the concrete.
- The concrete with Polypropylene fiber is most efficient in inducing the additional strength to the concrete when compared to Polyester fibers.
- The concrete with Polypropylene fiber is most economical when compared to polyester fibers.
- Compressive strength of polypropylene and polyester fiber reinforced concrete increased up to 0.3% of fiber content
- The Flexural strength of polypropylene and polyester fiber reinforced concrete increased up to 0.1% of fiber concrete from that point the flexural strength is decreased 0.2-0.3% by volume of concrete of fiber content.
- The flexural strength of polypropylene has higher values when contrasted with polyester fiber reinforced samples and control sample.
- So we conclude that the concrete with Polypropylene fiber by volume of concrete is efficient for Pavement Quality Concrete when compared to Control plain sample and Polyester fiber.

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