



e-ISSN: 2319-8753 | p-ISSN: 2320-6710

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International Journal of Innovative Research in  
**SCIENCE | ENGINEERING | TECHNOLOGY**



# INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

Volume 10, Issue 6, June 2021

**ISSN** INTERNATIONAL  
STANDARD  
SERIAL  
NUMBER  
INDIA

**Impact Factor: 7.512**



9940 572 462



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# Study on Rigid Pavements with Addition of Discrete Fiber

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**ABSTRACT:** Pavements have three types i.e. flexible pavements, rigid pavements, composite pavements. Nowadays rigid pavements had laid down in majority because of its better outcomes. Rigid pavements have combination of cement, fine aggregate, coarse aggregate, water and steel/admixtures if required. Rigid pavements are limited with some problems i.e. cracking, spelling, skidding etc., with the addition of some materials, pavements may fulfill the required parameters. The addition of these materials have basic requirements i.e. should be available easily, economical and fulfill the desired May 30, 2021 This study shall be focused on the use of discrete fiber material that will be better in tension and has better elastic/plastic characteristics.

**KEYWORDS:** Concrete, Cracks, Shrinkage, Polypropylene, Cement, Strength, Compressive.

## I.INTRODUCTION

Roads are chief means of transportation. It is used for the safe movement of vehicles. It is important to maintain for its long service. For the safe movement of traffic, the road pavement should be durable enough. The most important purpose of a pavement is to transfer loads to the sub-base. The benefit of using rigid pavement is its sturdiness and capability to tolerate hard environmental conditions. A rigid pavement is created from cement concrete or reinforcement concrete slab. A rigid road pavement provides an efficient, comfortable, and cost-effective design for the roadways and highways. Due to its high flexural stiffness and mechanical resistance, a rigid pavement allows to homogeneously transfer the vehicular loads to the underlying layers, preventing load and stress concentrations in the sub grade. But concrete pavements may suffer quick weakening, in the form cracks, fissures and failures, which can cause loss of serviceability and unsafe driving situation. This occurrence is chiefly due to the stiff behavior of cement concrete together with its little resistance to fatigue phenomena and its small resilience. Shrinkage cracking of concrete is a major problem in basic cement concrete pavements. Cracks play an important role as they change concrete structures into permeable elements and consequently with a high risk of corrosion. Cracks not only reduce the quality of concrete and make it aesthetically unacceptable but also make structures out of service. If these cracks do not exceed a certain width, they are neither harmful to a structure nor to its serviceability. Therefore, it is important to reduce the crack width and this can be achieved by adding polypropylene fibers to concrete. Thus addition of fibers in cement concrete matrix bridges these cracks and restrains them from further opening. However, these aspects can be diminished through the implementation of fibers.

Fiber reinforced concrete (FRC) is a concrete which contain fibrous materials that increase the structural integrity of concrete. Different sorts of fibers can be used in concrete to mend the properties of concrete. Each fiber has the ability to improve produce greater the quality of concrete. The fiber is added during the mixing of the concrete blend. The amount to be added is expressed in percentage to the total volume. . The fibers that can be used in concrete pavements to improve their strength are steel fiber, polypropylene fiber, and synthetic fiber. Each fiber has different properties which can enhance the quality of concrete. It depends on the quantity of the fiber added to the concrete mix by which it can improve the behavior of the concrete. Every fiber helps to prevent the tiny fissures that can occur when concrete's tensile strength is weakest. Although every type of fiber has been tried out in cement and concrete, not all of them can be effectively and economically used. Each type of fiber has its characteristic properties and limitations.

## II. LITERATURE REVIEW

1. **Saeed Ahmed, et al., (2006) [6]** deals with the effect of addition of various proportions of polypropylene fiber on the properties of concrete. Polypropylene is a synthetic hydrocarbon polymer, the fiber of which is made using extrusion processes by hot drawing the material through a die. Its uses enable reliable and effective utilization of intrinsic flexural and tensile strength of the material along with significant reduction of plastic shrinkage cracking and minimizing of thermal cracking. An experimental program was carried out to explore its effects on compressive, tensile and shear strength was found. It was observed that shrinkage cracking was reduced by 83% to 85% by addition of fibers in the range 0.35% to 0.50%.

2. **Hamid Pesaran Behbahani, et al., (2011) [9]** presents an overview of the mechanical properties of Steel Fiber Reinforced Concrete, its advantages and applications.

3. **Siddesh Pai, et al., (2013) [12]** used polyester fiber for improving the strength of concrete. The tests that were conducted included compression test, Ultrasonic pulse velocity (UPV) test, and modulus of rupture test. Test result indicated that the compressive strength of the concrete decreases as the percentage of fibers added increases. This theory is strengthened by similar values from the ultrasonic pulse velocity test. It is also seen from the results that the cubes and beams having 1% fiber mix is showing surface temperature lower than the specimens with 0.5% and 0% fiber. It can be concluded that as the percentage of fiber increases the specimen can handle high temperature and stays cool compared to the 0% fiber specimens.

4. **Kolli Ramujee, et al., (2013) [13]** interest in the use of fibers for the reinforcement of composites has increased during the last several years. A combination of high strength, stiffness and thermal resistance favorably characterizes the fibers. In this study, the results of the Strength properties of Polypropylene fiber reinforced concrete have been presented. The compressive strength, splitting tensile strength of concrete samples made with different fibers amounts varies from 0%, 0.5%, 1% 1.5% and 2.0% were studied. The samples with added Polypropylene fibers of 1.5 % showed better results in comparison with the others.

5. **S.A Kanalli, et al., (2014) [15]** used polypropylene fiber as it is one of the cheapest and abundantly available polymer. The various tests included the Compression Test, Tensile Strength Test, Flexural Test were performed using different proportions of polypropylene fiber resulted in improving strength parameters of concrete.

6. **Ms. Amreen N. Ali, et al., (2015) [16]** used Polymeric fibers are gaining popularity because of its properties like zero risk of corrosion and cost effectiveness. The polymeric fibers commonly used are polyester, Recon 3s, and polypropylene. Various tests were performed and it was concluded that Steel fiber reinforced concrete with 2% steel fibers yields slightly more stress as compared to 1% & 3% steel fiber reinforced concrete for both Positive curling temperature gradient & negative curling temperature gradient. Polypropylene fibers reduce the water permeability, plastic, shrinkage and settlement and carbonation depth. The problem of low tensile strength of concrete can be overcome by addition of polypropylene fibers to concrete.

## III. MATERIALS TO BE USED

Various materials to be used in this work were selected as per the availability, cost efficiency.

1. **Cement:** Cement is very important ingredient of concrete. It works as a binder. Its volume is very less than other materials in concrete. Generally, on the basis of grades of cement, we have three types:
  - 33 Grade
  - 43 Grade
  - 53 Grade

The different test results performed on cement are:

Ordinary Portland cement of 43 grade (Shree Ultra Cement)

S. No.	Properties	Observed values	Values specified by IS:8112-1989
1.	Fineness % (90 $\mu$ m I.S. Sieve)	3	Not more than 10
2.	Soundness (mm) (Le Chatelier Method)	1.0	Not more than 10
3.	Normal Consistency (%)	28	.....
4.	Initial Setting Time (minutes)	210	$\geq 30$
5.	Final Setting Time (minutes)	330	$\leq 600$
6.	Compressive Strength (MPa)		
	i) 3 days	36.40	$> 23$
	ii) 7 days	47.20	$> 33$
	iii) 28 days	54.70	$> 43$
7.	Specific gravity (Le-Chatelier's Method)	3.87	.....

Codes Used for testing; IS: 456-2000

IS: 10262-2009 and IS: 8112-1989.

2. Fine aggregate: Sand is a natural granular material which is mainly composed of finely divided rocky material and mineral particles. The most common constituent of sand is silica (silicon dioxide, or SiO<sub>2</sub>), usually in the form of quartz, because of its chemical inertness and considerable hardness, is the most common weathering resistant mineral. Hence it is used as fine aggregate in concrete. River sand and fly ash is commonly used as a fine ingredient (little to no amount) in pervious concrete. The exact definition of sand varies. As per US standard sieves, sand is defined as a particle size whose diameter varies from 0.074 and 4.75mm. The sand is commonly divided into five sub - categories based on size:
  - Very fine sand (1/16mm - 1/8mm diameter)
  - Fine sand (1/8mm – 1/4mm diameter) Medium sand (1/4 mm - 1/2 mm diameter)
  - Coarse sand (1/2mm - 1mmdiameter) Very coarse(1mm – 2mm diameter)

The different tests performed on fine aggregate are: Yamuna sand used conforms to zone II as per IS: 383-1970. Weight of Sample Taken=1000gm

IS Sieve Size	Weight Retained (gm)	Percentage Weight Retained (gm)	Cumulative percentage of Weight Retained	Percentage Passing
80 mm	0	0	0	100
40 mm	0	0	0	100
20 mm	1400	47	47	53
10 mm	1200	40	87	13
4.75 mm	400	13	100	0
2.36 mm	0	0	100	0
1.18 mm	0	0	100	0
600 micron	0	0	100	0
300 micron	0	0	100	0
150 micron	0	0	100	0
Total	3000	100	733.33	

$$\sum F = 297.7$$

Fineness Modulus (F.M.) = 2.97

Sand conforms to grading zone II of I.S. 383-1970

**Physical Properties of Fine Aggregate**

S. No.	Property	Observed Values
1.	Bulk Density (Loose), kg/m <sup>3</sup>	1691
2.	Bulk Density (Compacted), kg/m <sup>3</sup>	1876
3.	Specific Gravity	2.54
4.	Free Moisture %	1.51
5.	Water Absorption %	5.3

3. **Coarse Aggregate:** Concrete can be considered to be an artificial stone obtained by binding together the particles of relatively inert fine and coarse materials with cement paste. Aggregates are generally cheaper than cement and impart greater volume stability and durability to concrete. The aggregate is used primarily for the purpose of providing bulk to the concrete. To increase the density of the resulting mix, the aggregate is frequently used in two or more sizes i.e., coarse and fine aggregates. The aggregates provide about 75% of the body of the concrete and hence its influence is extremely important. They should therefore meet certain requirements if the concrete is to be workable, strong, durable, and economical. The aggregates must be of proper shape, clean hard, strong and well graded. It should possess chemical stability and in many cases exhibit abrasion resistance and resistance to freezing and thawing.



Tests performed on coarse aggregate:

IS Sieve Size	Weight Retained (gm)	Percentage Weight Retained (gm)	Cumulative percentage of Weight Retained	Percentage Passing
80 mm	0	0	0	100
40 mm	0	0	0	100
20 mm	1400	47	47	53
10 mm	1200	40	87	13
4.75 mm	400	13	100	0
2.36 mm	0	0	100	0
1.18 mm	0	0	100	0
600 micron	0	0	100	0
300 micron	0	0	100	0
150 micron	0	0	100	0
Total	3000	100	733.33	

Weight of Sample Taken = 3000gm

$$\Sigma F = 733.33$$

Fineness Modulus (F.M.) = 7.33

#### Physical Properties of Coarse Aggregate

S. No.	Property	Observed Values
1.	Bulk Density (Loose), kg/m <sup>3</sup>	1407
2.	Bulk Density (Compacted), kg/m <sup>3</sup>	1472
3.	Specific Gravity	2.64
4.	Free Moisture %	0
5.	Water Absorption %	1.5
6.	Impact Value (%)	21.9
7.	Crushing Value (%)	22.6

4. **Water:** Water plays a vital role in achieving the strength of concrete. For complete hydration it requires about 3/10th of its weight. It is practically proved that minimum water-cement ratio 0.35 is required for conventional concrete. Water participates in chemical reaction with cement and cement paste is formed and binds with coarse aggregate and fine aggregates. If more water is used, segregation and bleeding takes place, so that the concrete becomes weak, but most of the water will absorb by the fibers. Hence it may avoid bleeding. If water content exceeds permissible limits it may cause bleeding. If less water is used, the required workability is not achieved. Potable water fit for drinking is required to be used in the concrete and it should have pH value ranges between 6 to 9.

#### MIX PROPORTION:

- Grade designation = M25
- Cement type = Shree Ultra Cement grade 43
- Max. nominal size of aggregate = 10, 20mm



- Min. Cement content = 330kg/cu-m
- Max W/C ratio = 0.40
- Slump = 25mm
- Compaction Factor value = 0.77

S. No.	Cement	FA	CA	Water	Remark
1.	350	625	1247	140	By weight (kg/m <sup>3</sup> )

## 5. Fiber:

Fibers can play an important role in concrete reinforcement. However, not all fibers are the same. While many fibers can't replace the strength gained through steel reinforcement, most can still make concrete last longer and sometimes even achieve a specific look. Fibers are usually used in concrete to control cracking due to plastic shrinkage and to drying shrinkage. They also reduce the permeability of concrete and thus reduce bleeding of water. Some types of fibers produce greater impact, abrasion, and shatter resistance in concrete.

a) **Polypropylene Fiber:** Polypropylene fibers were first suggested as an admixture to concrete in 1965 for the construction of blast resistant buildings for the US Corps of Engineers. The fiber has subsequently been improved further and at present it is used either as short discontinuous fibrillated material for production of fiber reinforced concrete or a continuous mat for production of thin sheet components. Since then the use of these fibers has increased tremendously in construction of structures because addition of fibers in concrete improves the toughness, flexural strength, tensile strength and impact strength as well as failure mode of concrete. Polypropylene twine is cheap, abundantly available, and like all manmade fibers of a consistent quality.

b) **Polyester Fiber:** Polyester Fiber Reinforced Concrete (PFRC) has been evaluated for use as a cement concrete pavement material. It is concluded that polyester fibers are alkali resistant, and PFRC can be used in the pavement quality concrete (PQC), and as over lays, with no adverse effect on concrete.

## Test Procedure:

### 1. Compressive Strength Test:

In this test cubes were casted with the size of each cube as 150\*150\*150mm. Firstly moulds were prepared with plain concrete and its compressive strength was observed after 7, 14 and 28 days. Then fibers both (polypropylene and polyester) were added in the percentage of 0.4%, 0.8%, 1.2%, 1.6% and 2.0% each and similarly compressive strength was determined for 7, 14 and 28 days and the results of compressive strength of plain concrete was compared with that of the strength obtained by addition of fibers.

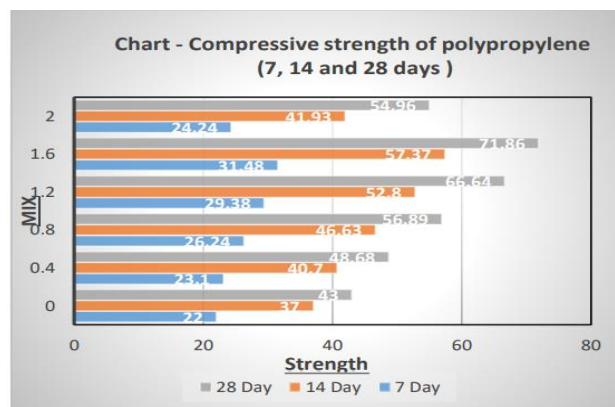
### 2. Flexural Strength Test:

In this beams were casted in the same way as cubes were casted for compressive strength. Firstly beams were prepared with plain concrete and the flexural strength was observed after 7, 14 and 28 days. Then fibers both (polypropylene and polyester) were added in the percentage of 0.4%, 0.8%, 1.2%, 1.6% and 2.0% each and similarly flexural strength was determined for 7, 14 and 28 days and the results of flexural strength of plain concrete was compared with that of the strength obtained by addition of fibers.

## V. RESULTS

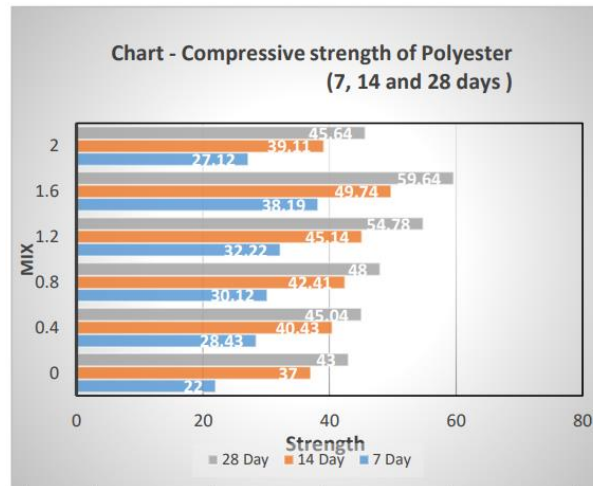
### Compressive Strength:

Trial	Polypropylene Fiber	7 days (N/mm <sup>2</sup> ) Avg.	14 days(N/mm <sup>2</sup> ) Avg.	28 days(N/mm <sup>2</sup> ) Avg.
1.	0	22	37	43
2.	0.4	23.10	40.7	48.68
3.	0.8	26.24	46.63	56.89
4.	1.2	29.38	52.80	66.64
5.	1.6	31.48	57.37	71.86
6.	2.0	24.24	41.93	54.96



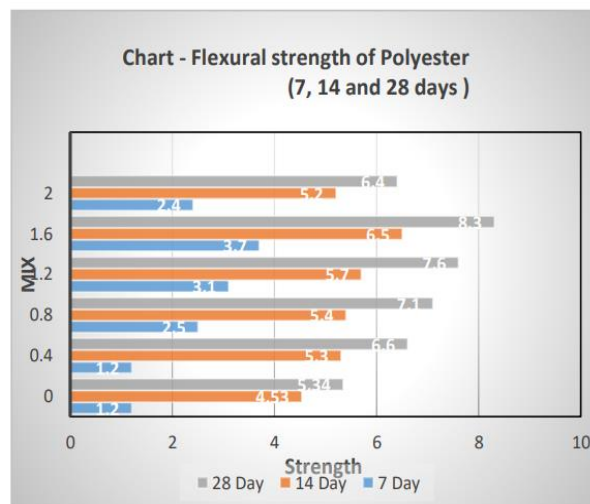
Trial	Polyester	7 days (N/mm <sup>2</sup> ) Avg.	14 days(N/mm <sup>2</sup> ) Avg.	28 days(N/mm <sup>2</sup> ) Avg.
1.	0	22	37	43
2.	0.4	28.43	40.43	45.04
3.	0.8	30.12	42.41	48.00
4.	1.2	32.22	45.14	54.78
5.	1.6	38.19	49.74	59.64
6.	2.0	27.12	39.11	45.64



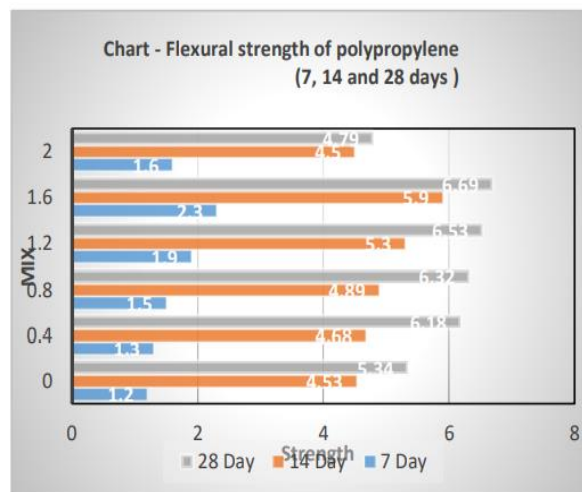


#### Flexural Strength:

Trial	Polyester Fiber	7 days (N/m m2) Avg.	14 days(N/m m2) Avg.	28 days(N/ mm2) Avg.
1.	0	1.2	4.53	5.34
2.	0.4	2.2	5.3	6.6
3.	0.8	2.5	5.4	7.1
4.	1.2	3.1	5.7	7.6
5.	1.6	3.7	6.5	8.3
6.	2.0	2.4	5.2	6.5



Trial	Polypropylene Fiber	7 days	14 days	28 days
1.	0.4	1.3	4.68	6.18
2.	0.8	1.5	4.89	6.32
3.	1.2	1.9	5.3	6.53
4.	1.6	2.3	5.9	6.69
5.	2.0	1.6	4.5	4.79



## VI. CONCLUSION AND SCOPE

### Conclusion:

- The Compressive Strength of Normal concrete mix is less than the compressive strength that was attained due to addition of fiber both polypropylene and polyester fiber with 1.6% of each and at 2.0% of polypropylene and polyester fiber it was observed that the compressive strength got decreased.
- The flexural strength of Normal concrete is less than the flexural strength that was attained due to addition of fiber both polypropylene and polyester fiber with 1.6% of each and at 2.0% of polypropylene and polyester fiber it was observed that the flexural strength got decreased.
- The addition of polyester fiber as well as polypropylene fiber in concrete showed an increment in the strength.
- It was seen that the maximum strength for both polypropylene and polyester fiber was obtained with 1.6% addition of this fiber to concrete.



## Scope:

The scope of the project is mentioned below:

As per literature survey it is clear that the improvement in strength has been observed by maximum researchers. With the help of these researches we can improve the properties of concrete. The fibers used in the concrete control cracking due to plastic shrinkage and drying shrinkage. Furthermore fibers used improve the structural strength. They reduce crack widths and control the crack widths tightly, thus improving durability. The toughness of fiber reinforced concrete is about 10 to 40 times that of plain concrete. The addition of fibers increases fatigue strength. The fibers used in this work are easily available and are cheap.

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