An Experimental study of using Polymer Fibre Reinforced Concrete in Pavement

[1]Priti, [2]Aman Bathla, [3]Dr. Gurcharan Singh

[1]M.tech Student, [2]Assistant Professor, [3]Head of Department
Civil Engineering Department,
Geeta Engineering College, Panipat, Haryana, India

***Abstract*: Fiber reinforced concrete pavements are more efficient than ordinary cement concrete pavement. "FRC is defined as composite material consisting of concrete reinforced with discrete randomly but uniformly dispersed short length fibers." The fibers may be of steel, polymer or natural materials. FRC is considered to be a material of improved properties and not as reinforced cement concrete whereas reinforcement is provided for local strengthening of concrete in tension region. Fibers generally used in cement concrete pavements are steel fibers and organic polymer fibers such as polyester or polypropylene. An experimental study of Polymer Fibre reinforced concrete has been presented in this study.**

***Keywords*: Fiber Reinforced Concrete, Pavements, FRC.**

I. INTRODUCTION

Concrete has better resistance in compression while steel has more resistance in tension. Conventional concrete has limited ductility, low impact and abrasion resistance and little resistance to cracking. A good concrete must possess high strength and low permeability. Hence, alternative Composite materials are gaining popularity because of ductility and strain hardening. To improve the post cracking behaviour, short discontinuous and discrete fibers are added to the plain concrete. Addition of fibers improves the post peak ductility performance, pre-crack tensile strength, fracture strength, toughness, impact resistance, flexural Strength resistance, fatigue performance etc. The ductility of fiber reinforced concrete depends on the ability of the fibers to bridge cracks at high levels of strain. Addition of polypropylene fibers decreases the unit weight of concrete and increases its strength. In a developing country such as India, road networks form the arteries of the nation. A pavement is the layered structure on which vehicles travel. It serves two purposes, namely, to provide a comfortable and durable surface for vehicles, and to reduce stresses on underlying soils. In India, the traditional system of bituminous pavements is widely used. Locally available cement concrete is a better substitute to bitumen which is the by product in distillation of imported petroleum crude. It is a known fact that petroleum and its by-products are dooming day by day. Whenever we think of a road construction in India it is taken for granted that it would be a bituminous pavement and there are very rare chances for thinking of an alternative like concrete pavements. Within two to three decades bituminous pavement would be a history and thus the need for an alternative is very essential. The perfect solution would be polymer fiber reinforced concrete pavements, as it satisfies two of the much-demanded requirements of pavement material in India, economy and reduced pollution. It also has several other advantages like longer life, low maintenance cost, fuel efficiency, good riding quality, increased load carrying capacity and im permeability to water over flexible pavements. Fiber reinforced concrete pavements are more efficient than ordinary cement concrete pavement. "FRC is defined as composite material consisting of concrete reinforced with discrete randomly but uniformly dispersed short length fibers." The fibers may be of steel, polymer or natural materials. FRC is considered to be a material of improved properties and not as reinforced cement concrete whereas reinforcement is provided for local strengthening of concrete in tension region. Fibers generally used in cement concrete pavements are steel fibers and organic polymer fibers such as polyester or polypropylene.

This is an environment friendly approach in the field of pavement construction as almost all sorts of polymer waste can be recycled and used as a reinforcing admixture in the concrete pavements. As waste polymers which are produced in large quantities are non-bio degradable they can cause immense environmental issues. Instead of disposing it we can efficiently make use of its properties in the pavement construction.

PROPERTIES OF POLYPROPYLENE FIBERS

The raw material of polypropylene is derived from monomeric C3H6 which is purely hydrocarbon. Its mode of polymerization, its high molecular weight and the way it is processed into fibers combine to give polypropylene fibers very useful properties as explained below:

- There is a sterically regular atomic arrangement in the polymer molecule and high crystalline. Due to regular structure, it is known as isotactic polypropylene.
- Chemical inertness makes the fibers resistant to most chemicals. Any chemical that will not attack the concrete constituents will have no effect on the fiber either. On contact with more aggressive chemicals, the concrete will always deteriorate first.
- The hydrophobic surface not being wet by cement paste helps to prevent chopped fibers from balling effect during mixing like other fibers.
- The water demand is nil for polypropylene fibers.
- The orientation leaves the film weak in the lateral direction which facilitates fibrillations. The cement matrix can therefore penetrate in the mesh structure between the individual fibrils and create a mechanical bond between matrix and fiber.

The fibers are manufactured either by the pulling wire procedure with circular cross section or by extruding the plastic film with rectangular cross-section. They appear either as fibrillated bundles, mono filament or microfilaments. The fibrillated polypropylene fibers are formed by expansion of a plastic film, which is separated into strips and then slit. The fiber bundles are cut into specified lengths and fibrillated. In monofilament fibers, the addition of buttons at the ends of the fiber increases the pull out load. Further, the maximum load and stress transfer could also be achieved by twisting fibers.

POLYMER FIBER REINFORCED CONCRETE (PFRC)

Polymeric fibers are gaining popularity because of its properties like zero risk of corrosion and cost effectiveness. The polymeric fibers commonly used are polyester, Recron 3s, and polypropylene. Various forms of recycled fibers like plastic, disposed tires, carpet waste and wastes from textile industry, and Forta Econo net, can also be used as fiber reinforcements. These fibers act as crack arresters, restricting the development of cracks and thus transforming a brittle material into a strong composite with superior crack resistance, improved ductility and distinctive post cracking behavior prior to failure. Concrete pavements may be weak in tension and against impact, but PFRC is a suitable material which may be used for cement concrete pavement as it possesses extra strength in flexural fatigue and impact etc. The usage of fibers in combination with concrete also results in a mix with improved early resistance to plastic shrinkage cracking and thereby protects the concrete from drying shrinkage cracks. It accomplishes improved durability and reduced surface water permeability of concrete. It reduces the risk of plastic settlement cracking over rebar. It enables easier and smoother finishing. It also helps to achieve reduced bleeding of water to surface during concrete placement, which inhibits the migration of cement and sand to the surface and the benefits of the above will be harder, more durable surface with better abrasion resistance. A uniform distribution of fibers throughout the concrete improves the homogeneity of the concrete matrix. It also facilitates reduced water absorption, greater impact resistance, enhanced flexural strength and tensile strength of concrete.

Results:

Table: Compressive strength of different specimens

Designation	Compressive strength in N/mm^2	
	7 Days	28 days
Control	19.58	32.31
C 1	20.41	36.75
C 2	23.56	39.32
C 3	22.64	37.39

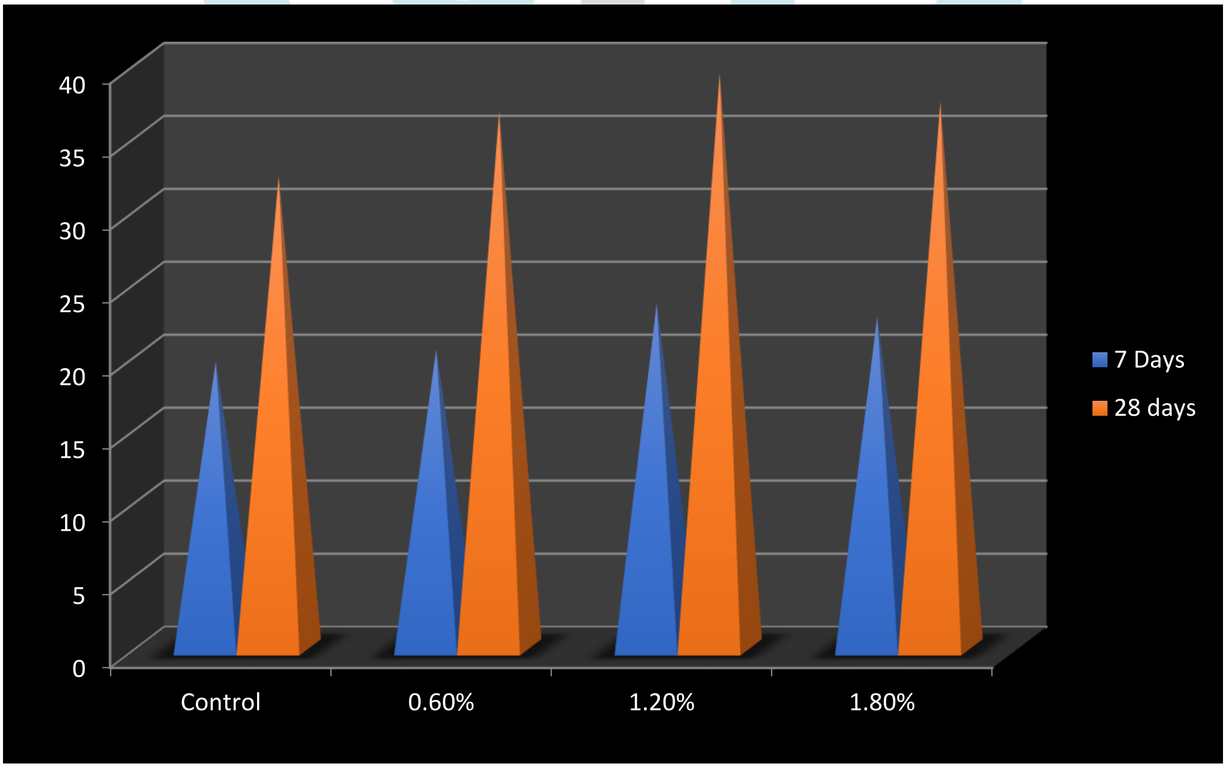

Figure: Compressive strength of various mixes

Table: Split tensile strength of different specimens

Designation	Split tensile strength in N/mm^2	
	7 Days	28 days
Control	1.53	2.52
C 1	1.56	2.76
C 2	1.68	2.86
C 3	1.65	2.74

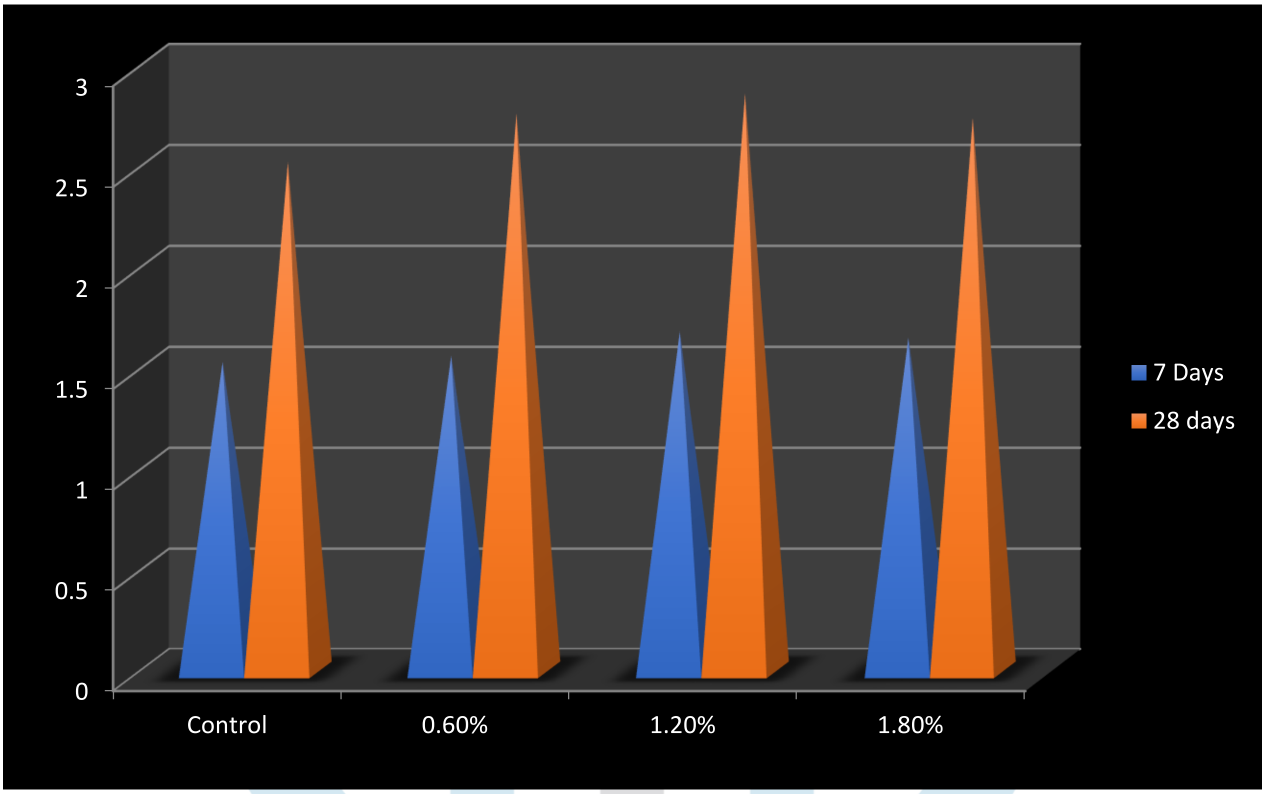

Figure: Split tensile strength of various mixes

Table: Flexural strength of different specimens

Designation	Split tensile strength in N/mm^2	
	7 Days	28 days
Control	3.58	7.93
C 1	4.27	8.54
C 2	4.97	9.87
C 3	4.57	7.58

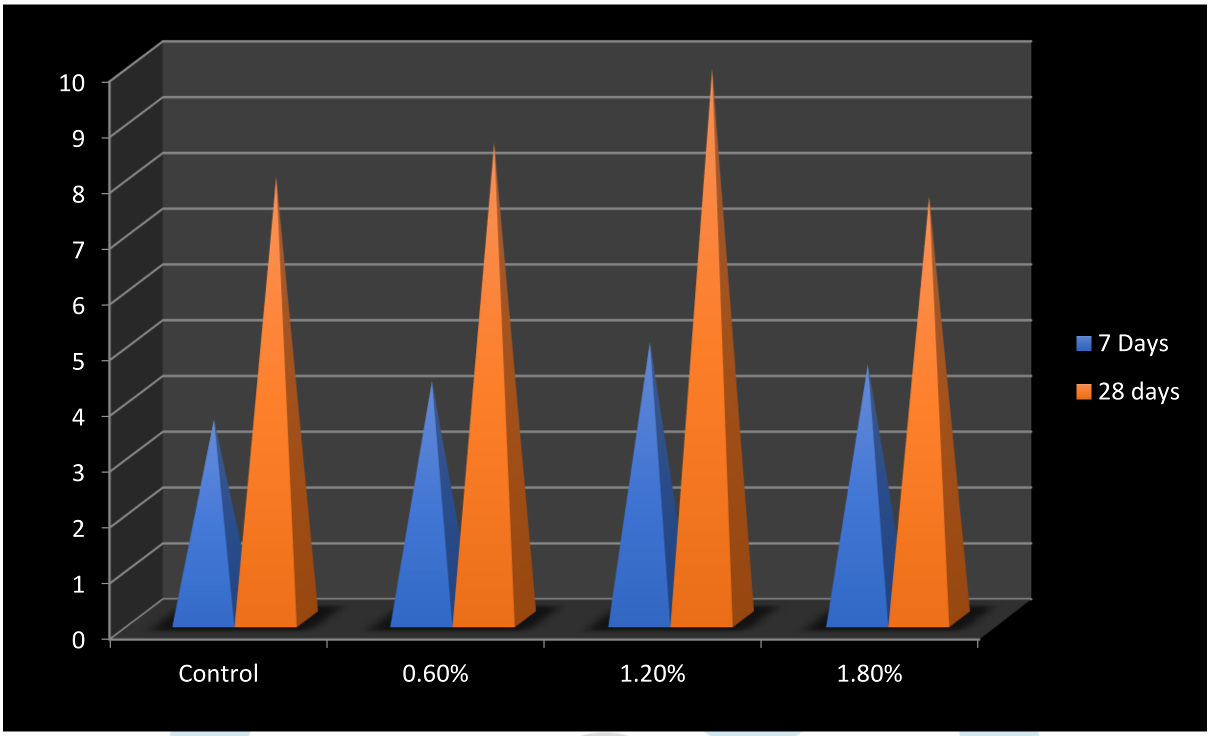

Figure: Flexural strength of various mixes

Conclusions

An experimental study of Polymer Fibre reinforced concrete has been presented in this study. On the basis of results obtained from this experimental investigation, following conclusions are drawn:

1. The compressive strength, split tensile strength, flexural strength and modulus of elasticity increase with the addition of fiber content as compared with conventional concrete. By replacing cement with polypropylene dosage it help to saving the cement content in concrete.
2. The slump value decreases with increasing the percentage of polypropylene fiber.
3. The growth of the amount of research and applications of steel fiber reinforced concrete (SFRC) and high performance concrete has been phenomenal in the past seven or eight years. High performance concrete has become widely accepted practically on all continents.
4. The compressive strength of normal concrete is less than the polypropylene fiber concrete but the increasing the % of Polypropylene in concrete mixes, it decreased the value of strength up to 1.5% of replacing cement with fiber in concrete mix.
5. The Flexural strength of normal concrete is less than the polypropylene fiber concrete but the increasing the % of Polypropylene in concrete mixes, it decreased the value of strength up to 1.5% of replacing cement with fiber in concrete mix.
6. The problem of low tensile strength of concrete can be overcome by addition of polypropylene fibers to concrete.
7. Polypropylene fibers reduce the water permeability, plastic, shrinkage and settlement and carbonation depth.
8. The split tensile strength of normal concrete is less than the polypropylene fiber concrete but the increasing the % of Polypropylene in concrete mixes, it decreased the value of strength up to 1.5% of replacing cement with fiber in concrete mix.
9. A generalized definition of high-performance concrete seems to have been accepted by the engineering community. Such a definition is based on achievement of certain performance requirements or characteristics of concrete for a given application that otherwise cannot be obtained from normal concrete as a commodity product. In many applications use of fiber is mandatory
10. Concrete reinforced with polypropylene fibrillated fiber may be used in the construction of concrete pavements.
11. The initial cost of fiber reinforced concrete pavements are high upto 15-20% but the maintenance cost is very low which takes to the overall cost to the level of 25-30%.
12. In the new era FRC will be taken as the major contributor to a country's economy and is said to be the true roads of a country.
13. Addition of polypropylene fiber in concrete, the pavement thickness is decreased by 20% and which is economical when compared to plain cement concrete.
14. Polypropylene fibers enhance the strength of concrete, without causing the well known problems, normally associated with steel fibers.
15. Polypropylene fibre can be used with admixtures, plasticizers, and super plasticizers, for increasing the strength of concrete with partial replacement of cement.
16. Polypropylene fibre is Reduce number of joints and Reduce repair due to subsequent damage.

17. The workability of Polypropylene fibre concrete has been found to decrease with increase in Polypropylene fibre content replacement.

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