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EXPERIMENTAL STUDY OF POLYMER FIBRE REINFORCED CONCRETE WITH CONVENTIONAL CONCRETE PAVEMENT

Tariq Ahmad Sheikh[1], Er. Jyoti Narwal[2]
M.tech Scholar in GEC, Panipat,
Assistant Professor in Civil Engineering, GEC, Panipat

Abstract: 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 byproducts 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. The mix design has been done by trial and error method. The mix proportions are calculated as per IS code. The ingredients of concrete M30 grade proportion are shown below table3.4. The raw materials are mixed through hand mixing and compacted through the vibrators of casted cubes and beams. The total mixing time was 3 minutes; the samples were then casted and left for 24 hrs before demoulding .They were then placed in the curing tank. Water absorption capacity and moisture content were taken into consideration and appropriately subtracted from the water/cement ratio used for mixing. The w/c ratio is taken 0.5% for all the mixes. Hence, cement was replaced in percentages of 0%, 0.6%, 1.2%, 1.8% with Polypropylene fibre 150 × 150 × 150mm, Beam and Cylinder moulds were used for casting.

1.0 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 impermeability 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.

1.1 ROLE OF FIBERS

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. In order to achieve more deflection in the beam, additional forces and energies are required to pull out or fracture the fibres. This process, apart from preserving the integrity of concrete, improves the load-carrying capacity of structural member beyond cracking. This improvement creates a long post-peak descending portion in the load deflection curve .Reinforcing steel bars in concrete have the same beneficial effect because they act as long continuous fibres. Short discontinuous fibres have the advantage, however, of being uniformly mixed and dispersed throughout the concrete. The major reasons for crack formation are Plastic shrinkage, Plastic settlement, Freeze thaw damage, Fire damage etc.

1.2 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.

2.2 LITERATURE ON POLYMER FIBRE REINFORCED CONCRETE

T.Subramani et al (2016) analysed the Polymer Fibre Reinforced Concrete Pavements by Using ANSYS. In this study an assessment of the performance of polymeric concrete with synthetic fibre reinforcement against reflective cracking in an overlay system. The performance of polymeric concrete with synthetic fibres as an overlay material is measured in terms of the load-deflection, strain-deflection and load-strain behaviour of beams of the polymeric concrete. For this purpose, five types of beams having different number of fibre wires and position are tested for flexure strength. Deflection/strains for each increment of load are recorded. In addition, cubes of plain concrete and of concrete with synthetic fibre needles were tested after 7 and 28 days for compressive strengths. Finite element models in ANSYS software for the beams have also been developed. Beams with greater number of longitudinal fibre wires displayed relatively better performance against deflection whilst beams with synthetic fibre needles showed better performance against strains. Thus, polymeric concrete overlay with fibre reinforcement will serve relatively better against occurrence of reflective cracking. Cement concrete pavements are used for heavy traffic loads throughout the world owing to its better and economical performance. Placing of a concrete overlay on the existing pavement is the most prevalent rehabilitating method for such pavements however the problem associated with the newly placed overlay is the occurrence of reflective cracking.

Ankit N. Pansuriya et al (2016) studied the use of use of polypropylene fiber in rigid pavement. This study manages exploratory examination on mechanical properties of M30grade concrete by adding polypropylene fibers in the blend at measurements of 0.5%, 1%, 1.5%, 2%, 2.5% by weight of cement added to the mix. A comparative analysis has been carried out for conventional concrete to that of the fiber reinforced in relation to compressive, tensile and flexural strengths. The study concluded that 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. And 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.

U. B. Kalwane et al (2016) studied the toughness of polymer modified steel Fiber reinforced concrete. In this study an experimental investigation is carried out to study the toughness of polymer modified steel fiber reinforced concrete. Volume fraction of steel fibers is varied from 0% to 7% at the interval of 1% by weight of cement. 15% SBR latex polymer was used by weight of cement. Cubes of size 150 × 150 × 150 mm for compressive strength, prism specimens of size 150 mm × 150 mm × 700 mm for flexure strength and, specimen of size 150 × 150 × 150 mm with 16 mm diameter tor steel bar of length 650 mm embedded in concrete cube at the center for bond test were prepared. Various specimens were tested after 28 days of curing. Area under curve (toughness) is measured and mentioned in this work. An experimental study of toughness of PMSFRC has been presented in this study. On the basis of results obtained from this experimental investigation, following conclusions are drawn and it is observed that the strain softening, which is an increase in strain under constant load, is evident in inelastic range in compression. The elastic strain capacity increased with the increase in fiber volume fraction. The maximum compression toughness is observed at 1% of fiber content and the addition of fibers and polymer increased the flexural toughness at 7% of fiber content.

T.Sirisha et al (2016) studied the use of Discrete Fiber in Construction. To overcome shrinkage cracking of plain concrete, sometimes the addition of synthetic fiber to the concrete mix is suggested. This paper briefly discusses the effects of addition of polypropylene discrete and fibrillated fibre on the properties of a paving grade concrete mix of 48 MPa compressive strength at 28-day. Six concrete mixes with fiber dosages 0.05%, 0.10% and 0.15% by volume fraction besides the control concrete mix were manufactured. Discrete and fibrillated polypropylene fiber was used in this study. The properties such as settlement, compressive strength, drying shrinkage, and abrasion resistance of the concrete were evaluated. The study suggested a significant reduction in settlement and drying shrinkage without significant change in compressive strength for the concrete mixes reinforced with fiber. Further, an improved abrasion resistance for the concrete mixes reinforced with fibre was also observed. Following conclusions are drawn based on the previous & present experimental study on SFRC and new generation high performance fiber reinforced concrete:

1. 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.
2. 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.

Pawan Kumar et al (2016) Studied on polypropylene fiber reinforced concrete with conventional concrete pavement design. Transportation always plays a key role in the development of the country. In India, Bituminous pavements are mostly used across the country. Bitumen are obtained by petroleum crude which is used for the making the flexible pavements. As we know, Petroleum crude are gradually diminished on the earth, so there is a need to replace the bitumen pavement by cement concrete pavement. Cement concrete pavement has several advantages like providing smooth ride surface, high compressive strength, etc. But there are several disadvantages that is its low tensile strength, proper need to maintenance and repairing, low durability etc. Polypropylene fiber reinforced concrete pavement has better solution for overcoming the problems related to cement concrete pavement. PPFRC pavements provide better paving road, smart grip to tyres, high flexural strength and high durability. It also provides better solution frequently maintenance and repairing of the cement concrete pavements. The addition of polypropylene fibers makes it proper binding of the concrete ingredients and gets homogeneous fiber concrete. In this experiment we are analysed to get the optimum strength behaviour of polypropylene fiber reinforced concrete by adding the different percentage of polypropylene fiber by volume of concrete. From the experiment, the following results are concluded that compressive Strength increases with adding the percentage of polypropylene fiber. Compressive strength gets maximum at a particular percentages of fibers (here 1.50%) and then decreases with adding the fibers.and flexural strength increases with increasing the percentage of polypropylene fiber. The maximum flexural strength has obtained at 2.00% of polypropylene fiber by volume of concrete.

3.0 MIX PROPORTION

The mix design has been done by trial and error method. The mix proportions are calculated as per IS code. The ingredients of concrete M30 grade proportion are shown below table 1. The raw materials are mixed through hand mixing and compacted through the vibrators of casted cubes and beams. cement was replaced in percentages of 0%, 0.6%, 1.2%, 1.8% with Polypropylene fibre 150 × 150 × 150mm, Beam and Cylinder moulds were used for casting. The concrete was left in the mould and allowed to set for 24 hours before the cubes were demoulded and placed in curing tank.

Table 1: Mix Specification for 1 cubic meter Concrete

DESIGNATIONS	C 0	C1	C2	C3
Particulars	**Plain concrete mix**	**0.6%**	**1.2%**	**1.8%**
Cement in kg/m^3	397	394.618	392.236	389.854
Sand in kg/m^3	632.29	632.29	632.29	632.29
Coarse aggregate in kg/m^3	1212.76	1212.76	1212.76	1212.76
Polypropylene	0	2.382	4.764	7.146

4.1 COMPRESSIVE STRENGTH TEST

The compression test was performed to find out compressive strength of polymer modified steel fiber reinforced concrete on test specimens cubical in shape of size 150 mm × 150 mm × 150 mm, confirming to IS: 10086-1982.

Table 2: 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

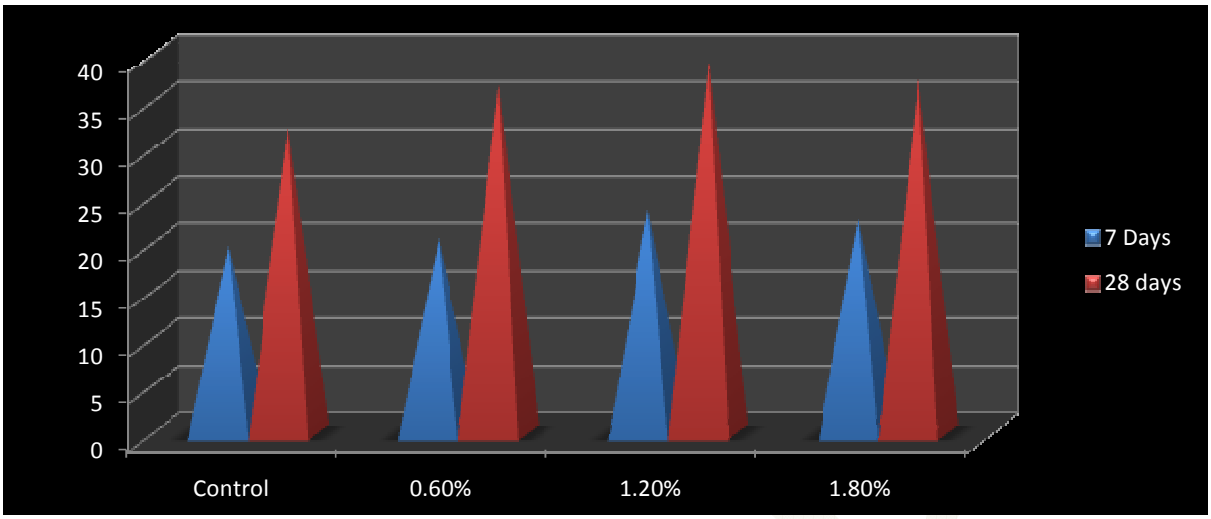

Figure 1: Compressive strength of various mixes

4.2 SPLIT TENSILE STRENGTH TEST

The cylinder of diameter mm and of height 300 mm is casted and tested for the tensile strength with the varying ratio of fiber dosage ranging from 0.6 % of volume of concrete. The cylinder specimen was placed horizontally in the centering with packing skip (wooden strip)/or loading pieces carefully positioned along the top and bottom of the plane of loading of the specimen

Table 3: 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

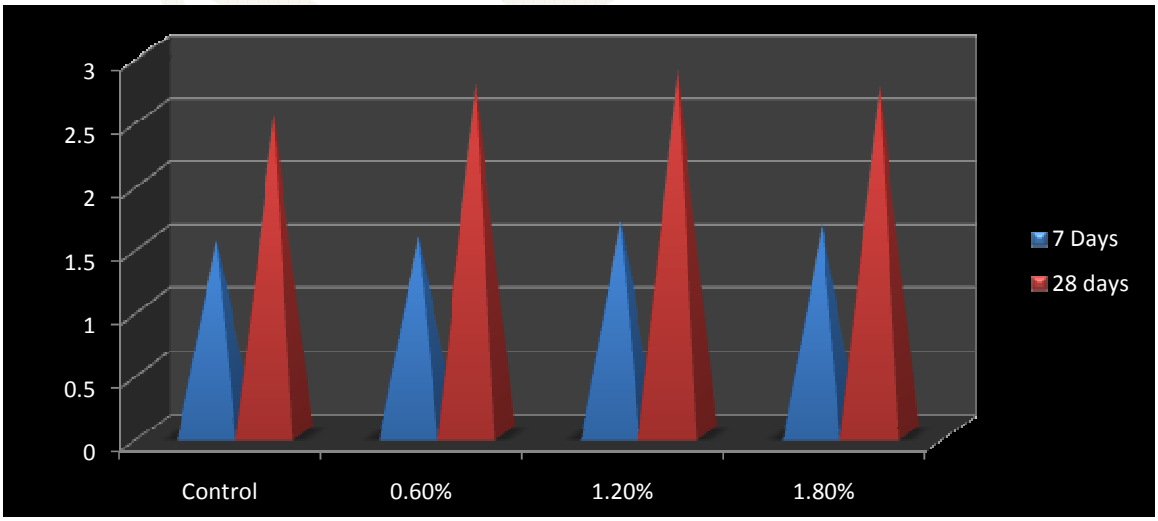

Figure 2: Split tensile strength of various mixes

CONCLUSION

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 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.
4. 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.
5. The problem of low tensile strength of concrete can be overcome by addition of polypropylene fibers to concrete.
6. Polypropylene fibers reduce the water permeability, plastic, shrinkage and settlement and carbonation depth.
7. 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.

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