

Performance Evaluation of Concrete Containing Polypropylene and Recron Fiber as Additive

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(MS received August 15, 2014; revised November 20, 2014)

Abstract

In conventional concrete, micro cracks develop even before loading because of drying shrinkage and other causes of volume change. When the structures are loaded the micro cracks open up and propagate which may lead to chloride and sulphate attacks. Addition of closely spaced and uniformly dispersed fibers substantially improves the properties of concrete. These fibers offer increased resistance to crack growth, through a crack arresting mechanism and improve tensile strength and ductility of concrete. Adding excess fibers to concrete result in reduction of concrete strength. An experimental study was carried out to determine the optimum percentage of polypropylene and recron fiber that can be used with concrete to enhance the compressive and tensile strength of concrete.

Keywords: Fiber, Concrete, Polypropylene Fibers, PPF, Recron Fibers

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1. Introduction

Portland cement concrete is considered to be a relatively brittle material. When subjected to tensile stresses, non-reinforced concrete will crack and fail. Since mid 1800's steel reinforcing has been used to overcome this problem. As a composite system, the reinforcing steel is assumed to carry all tensile loads.

The steel reinforcement in concrete corrodes due to the ingress of chloride ions. In coastal areas, chloride penetration in concrete is very common which leads to corrosion. The volume expansion due to corrosion imparts stresses in the concrete, which initiates cracks and results in concrete spalling from the surface [1]. Although some measures are available to reduce corrosion of steel in concrete such as corrosion inhibitive admixtures and coatings, a better and permanent solution is to replace the steel with a reinforcement which is more durable, which brings us to Poly Propylene Fibers and Recron Fibers. These fibers not only

help in increasing the tensile strength of structure but also help to make the concrete more durable.

When the loads imposed on concrete approach the failure load, cracks propagate rapidly, fibers in concrete provide a means of arresting the crack growth. Reinforcing steel bars in concrete have the same beneficial effect because they act as long continuous fibers. Short discontinuous fibers have the advantage of being uniformly mixed and dispersed throughout the concrete.

Fiber Reinforced Concrete (FRC) is Portland cement concrete reinforced with more or less randomly distributed fibers. In FRC, small fibers are dispersed and distributed randomly in the concrete during mixing. Several different types of fibers, both manmade and natural, have been incorporated into concrete. Use of natural fibers in concrete precedes the advent of conventional reinforced concrete in historical context. However, the technical aspects of FRC systems remained essentially undeveloped.

Since the advent of fiber reinforcing of concrete in the 1940's, a great deal of testing has been conducted on the various fibrous materials to determine the actual characteristics and advantages for each product.

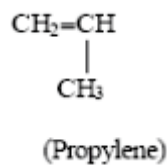
The choice of fibers varies from synthetic organic materials such as polypropylene, recron or carbon, synthetic inorganic such as steel or glass, natural organic such as cellulose or sisal to natural inorganic asbestos. The selection of the type of fibers is guided by the properties of the fibers such as diameter, specific gravity, young's modulus, tensile strength etc and the extent these fibers affect the properties of the cement matrix. We have used Poly Propylene Fibers (PPF) and Recron Fibers (RF) for our experimental setup.

These synthetic fibers are man-made fibers are obtained from petrochemical and textile industries. Polypropylene fibers are extruded from olefin resin and today are being used extensively in all types of concrete construction.

2. Material

2.1 Polypropylene Fibers (PPF)

Polypropylene (PPF) is a versatile thermoplastic material, which is produced by polymerizing monomer units of polypropylene molecules into very long polymer molecules or chains in the presence of a catalyst under carefully controlled heat and pressure. Propylene is an unsaturated hydrocarbon, containing only carbon and hydrogen atoms:



Polypropylene is one of the fastest growing classes of fibers. Specifications of Polypropylene fibers are shown in Table I.

Table 1: Polypropylene fiber specifications

| | |
|--------------------------------------|---------|
| Color | White |
| Specific weight [g/cm ³] | 0.95 |
| Diameter [μm] | 20-200 |
| Modulus of elasticity [GPa] | 5 - 10 |
| Tensile strength [MPa] | 500-750 |
| Melting point [°C] | 160 |
| Bonding with cement | Good |
| Stability in cement | Good |



Figure 1: Polypropylene Fibers

2.2 Recron Fibers (RF)

Table 2: Specifications of recron fiber

| | |
|-------------------|---------------------------|
| Tensile Strength | ~ 6000 kg/cm ² |
| Melting point | > 250°C |
| Dispersion | Excellent |
| Acid resistance | Excellent |
| Alkali resistance | Good |

3. Experimental Setup

Several series of Concrete Cubes and Beams of dimensions 150 mm x 150 mm x 150 mm and 500mm x 100mm x 100mm respectively[2], were prepared at a water/cement ratio of 0.40 to make M25 Grade [3] concrete by mechanical

pugging and compacting in moulds by a vibration table machine.

According to the mechanical test norms of cement concrete, three concrete cubes were casted without any addition as the reference sample. The specimens were cured in curing tank at 27 °C for gaining 28 days compressive and flexural strength [4]. Other samples were casted by replacing different percentage by weight of cement with Poly Propylene and Recron Fibers.

Poly Propylene Fiber Cubes and Beams were casted under 6 categories:

1. PPF 0: Standard M25 Grade of Concrete
2. PPF 1: M25 Concrete + 0.2% PPF
3. PPF 2: M25 Concrete + 0.4% PPF
4. PPF 3: M25 Concrete + 0.6% PPF
5. PPF 4: M25 Concrete + 0.8% PPF
6. PPF 5: M25 Concrete + 1.0% PPF

Similarly, Recron Fiber Cubes and Beams were casted under 6 categories:

1. RF 0: Standard M25 Grade of Concrete
2. RF 1: M25 Concrete + 0.2% RF
3. RF 2: M25 Concrete + 0.4% RF
4. RF 3: M25 Concrete + 0.6% RF
5. RF 4: M25 Concrete + 0.8% RF
6. RF 5: M25 Concrete + 1.0% RF

Cubes of size 150mm X 150mm X 150mm and Beams of Size 500mm X 100mm X 100mm were used for entire experimental setup. After the preparation of samples and 28 days curing, compressive strength tests were performed on the cubes and flexural tensile strength tests on the beams to study the effect of different dosage of fibers in concrete.

4. Results and Discussion

4.1 Poly Propylene Fiber Cubes

Compressive Strength of Cubes casted with

Poly Propylene Fibers:

Table 3: Compressive Strength Of PPF Concrete Cubes

| Category | Failure Load (kN) | Compressive Strength (N/mm ²) |
|----------|-------------------|---|
| PPF 0 | 643.5 | 28.6 |
| PPF 1 | 699.75 | 31.1 |
| PPF 2 | 612 | 27.2 |
| PPF 3 | 535.5 | 23.8 |
| PPF 4 | 492.75 | 21.9 |
| PPF 5 | 452.25 | 20.1 |

The Compressive Strength of Concrete shows very little improvement after addition of Polypropylene Fibers. Compressive Strength increased by 8% when 0.2% fibers were added (PPF 1). On further increasing the dosage of Polypropylene Fibers, the compressive strength of concrete decreased steadily. The influence of increasing percentage of polypropylene fiber is shown in Fig.2.

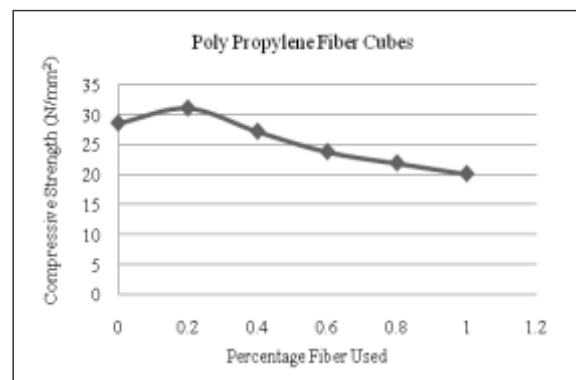


Figure 2: Influence of varying dosage of polypropylene fibers on compressive strength of concrete.

4.2 Poly Propylene Fiber Beams

Flexural Tensile Strength of Beams casted with Poly Propylene Fibers:

Table 4: Flexural Strength of PPF Concrete Beams

| Category | Failure Load (kN) | Compressive Strength (N/mm ²) |
|----------|-------------------|---|
| PPF 0 | 13.6 | 6.8 |
| PPF 1 | 20 | 10 |
| PPF 2 | 22.66 | 11.33 |
| PPF 3 | 24.66 | 12.33 |
| PPF 4 | 22.66 | 11.33 |
| PPF 5 | 15.66 | 7.83 |

The flexural strength of concrete shows excellent improvement after addition of Polypropylene Fibers. Flexural strength increased by 82% when 0.6% fibers were added (PPF 3). On further increasing the dosage of Polypropylene Fibers, the flexural strength of concrete decreased.

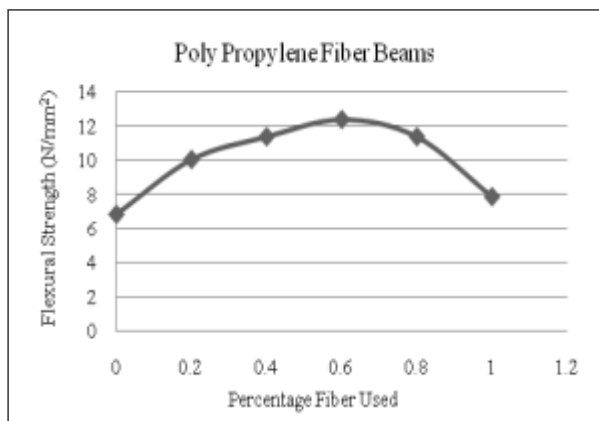


Figure 3: Influence of varying dosage of polypropylene fibers on flexural strength of beams.

4.4 Recron Fiber Cubes

Compressive Strength of Cubes casted with Recron Fibers is given in Table 5.

Again, the compressive strength of concrete

shows very little improvement after addition of Recron Fibers. Compressive Strength increased by 12% when 0.2% fibers were added (RF 1). On further increasing the dosage of Recron Fibers, the compressive strength of concrete decreased steadily.

Table 5: Compressive Strength of RF Concrete Cubes

| Category | Failure Load (kN) | Compressive Strength (N/mm ²) |
|----------|-------------------|---|
| RF 0 | 643.5 | 28.6 |
| RF 1 | 726.75 | 32.3 |
| RF 2 | 594 | 26.4 |
| RF 3 | 508.5 | 22.6 |
| RF 4 | 459 | 20.4 |
| RF 5 | 400.5 | 17.8 |

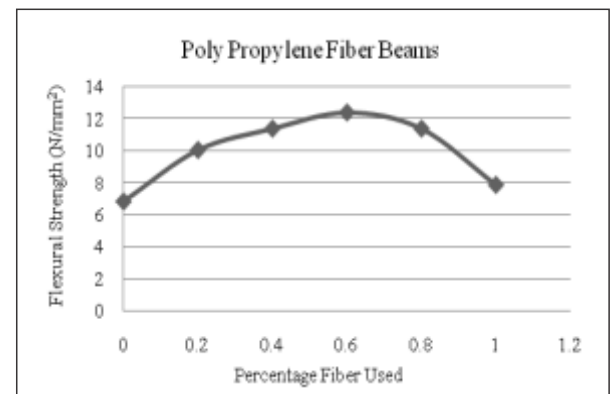


Figure 4: Influence of varying dosage of recron fibers on compressive strength of concrete.

4.5 Recron Fiber Beams

Flexural Tensile Strength of Beams casted with Recron Fibers is given in Table 6.

The flexural strength of concrete shows improvement after addition of Recron Fibers. Flexural strength increased by 37% when 0.4% fibers were added (RF 2). On further increasing

the dosage of Recron Fibers, the flexural strength of concrete decreased.

Table 6: Flexural strength of RF concrete beams

| Category | Failure Load (kN) | Compressive Strength (N/mm ²) |
|----------|-------------------|---|
| RF 0 | 13.6 | 6.8 |
| RF 1 | 14.66 | 7.33 |
| RF 2 | 18.66 | 9.33 |
| RF 3 | 18 | 9 |
| RF 4 | 16 | 8 |
| RF 5 | 14.4 | 7.2 |

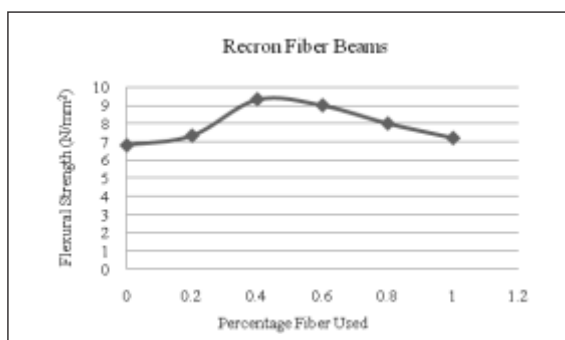


Figure 5: Influence of varying dosage of recron fibers on flexural strength of beams

5. Conclusions

Several cubes & beams of M25 grade concrete were casted with and without the addition of different percentage of Poly Propylene and Recron Fiber. Their compressive strength and flexural tensile strength was computed. On the basis of this study, the following conclusions may be drawn:

- 1) The influence of both Polypropylene and Recron Fiber is very less on Compressive Strength of Concrete. Maximum 8% increase in compressive strength was observed on addition of 0.2% Fiber to

concrete.

- 2) Polypropylene fiber shows excellent improvement in flexural tensile strength of concrete. Flexural strength of concrete show an increase of maximum 82% by adding 0.6% Polypropylene Fiber to concrete.
- 3) Recron fiber also shows good improvement in flexural tensile strength of concrete. Flexural strength of concrete show an increase of maximum 37% by adding 0.4% Recron Fiber to concrete.

Acknowledgment

We would like to thank Dr. K.K. Jain – Dean and HOD Civil Department, and Dr. N.J. Rao – Director, Jaypee university of Engineering & Technology, Guna, for their continuous support and guidance throughout our work.

References

1. A. M. Neville, Properties of Concrete, 4th ed., Pearson Publications, 563.
2. IS 456:2000 Plain and Reinforced Concrete – Code of Practice (Fourth Revision), 15.
3. IS 10262:1982 Recommended Guidelines for Concrete Mix Design, 8.
4. IS 516:1959 Methods of Test for Strength of Concrete, 8.
5. M. L. Gambhir, Concrete Technology, Tata Mc Graw Hill Publishing company.
6. R. Brown, A. Shukla and K. R. Natarajan, Fiber Reinforcement of Concrete Structures, University of Rhode Island, U.S.A, (2002).
7. M. A. Mansur and K.C.G. Ong, ACI

- Structural J., 88(1), (1991), 98-105. 177-188.
8. C. Alonso, L. Fernandez - Municio, Fire Design of concrete structures- From materials modelling to structural performance, International Workshop, University of Coimbra, Portugal, (2007), 69-78.
 9. C. Alonso, C. Andrade, E. Gallo, and E. Menendez, ACI International, SP- 229, (2005), 289-302.
 10. C. Alonso, C. Rodriguez, C. Andrade and J. Arlaud, Microstructural analysis of high performance concrete under fire. Improving resistance through the use of fibers” ECOMAS, Venice, (2008).
 11. R. Jansson and L. Bostron, Experimental study of the influence of polypropylene fibers on material properties and fire spalling of concrete, Proceedings of the international workshop fire design of concrete structures from materials modelling to structural performance, University of Coimbra, Portugal, (2007),
 12. P. Kalifa, G. Chene and C. Calle, Cement and Concrete Research, 31(10), (2001), 1487-1499.
 13. G.A. Khoury, C. Majorana, Polypropylene fibers and explosive spalling”, Proceedings of the international workshop fire design of concrete structures from materials modelling to structural performance, University of Coimbra, Portugal, (2007),. 211-224.
 14. S. Suhaendi and T. Horiguchi, Explosive spalling mitigation mechanism of fiber reinforced high strength concrete under high temperature condition, Proceedings of the international workshop fire design of concrete structures from materials modelling to structural performance, University of Coimbra, Portugal, (2007), 189-197.

