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Synthetic Fiber Reinforced Concrete

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***Abstract*—Properties of concrete are generally improved by mixing with it another material. In this work our aim was at strengthening the concrete by mixing it with polypropylene fibers. The effect of mixing on properties such as compressive strength, split tensile strength, flexural strength and workability were observed for different percentages of fiber.**

I. INTRODUCTION

Concrete is common building material and its property to get molded into any form gives it an advantage over brick. Since it is a major construction material in civil engineering, it should have more than sufficient strength to bear the loads acting on it. Therefore it becomes an important task to make concrete with desirable compressive and flexural strength. Fiber reinforced concrete (FRC) is concrete mix with a fibrous material to increase its structural integrity. It contains short discrete fibers which are uniformly distributed and randomly oriented. Fibers include steel fibers, glass fibers, synthetic fibers and natural fibers- each of which lend varying properties to the concrete. Fibers arrest the crack and also restrict the development of cracks and thus changing a brittle matrix into a strong composite with improved ductility and superior crack resistance. Thus addition of fibers into concrete makes the concrete more durable and strong. In this project M25 grade of concrete was prepared by natural sand procured from a river, coarse aggregate in the form of crushed stone with size 20 mm.

II. OBJECTIVE OF PRESENT STUDY

- Improve freeze-thaw resistance
- Improve resistance to explosive spalling in case of a severe fire
- Improve impact– and abrasion–resistance
- Increase resistance to plastic shrinkage during curing
- Improve structural strength
- Reduce steel reinforcement requirements
- Improve ductility
- Reduce crack widths and control the crack widths tightly, thus improving durability

III. MATERIALS USED

A. Polypropylene fiber:

Polypropylene is available in two forms, monofilament fibers and film fibers. It is a thermoplastic polymer which is used in a wide variety of applications including packing. It is widely use in ready mix concrete and it is easily available. Following are the few properties of polypropylene fiber:

- Polypropylene (PP) is a lightweight fiber.
- It does not absorb water. It presents that it has good resistance towards water absorb.
- Polypropylene has excellent chemical resistance. PP fibers are very resistant to most acids and alkalis.
- It has a melting point of 165^0 C and can withstand a temperature of 100^0 C for a short time before softening.

B. Cement:

The cement used was ordinary Portland cement with a specific gravity of 3.15. Initial and final setting time of the cement was 69 min. and 195 min. respectively.

C. Aggregates:

The coarse aggregates used in this experimental investigation pass through 20mm sieve and are retained on 10 mm sieve. Shape was angular. And aggregates were free of dust.

IV. BEHAVIOUR OF CONCRETE REINFORCED WITH POLYPROPYLENE FIBER

A. Compressive strength:

Samples were prepared using different percentages of polypropylene fiber i.e. 0.25%, 0.5%, 0.75% and 1.00%. Tests were done at recognized ages of the test specimens, usually being 7 and 28 days. The ages were calculated from the time of the addition of water to the drying of ingredients. At least three specimens, preferably from different batches, were taken for testing at each selected age. The results of compressive strength test shows that the compressive strength of concrete increases with the increase of fiber percentage up

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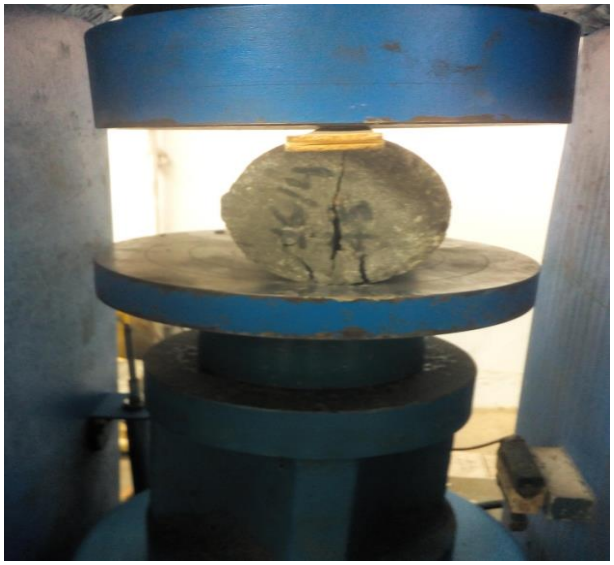
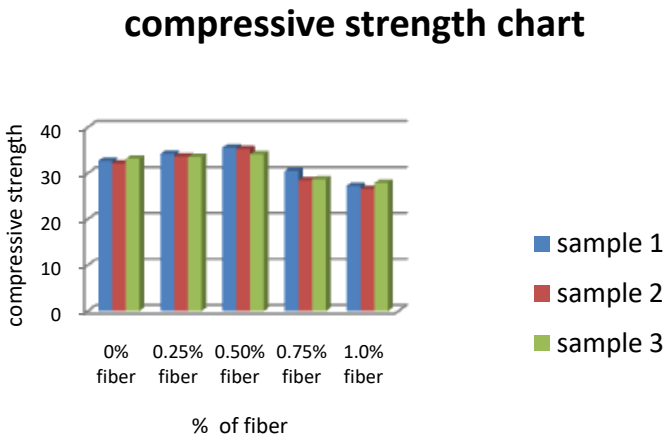
to 0.5% fiber content and then drastically decreases from 0.5% to 1.0% fiber content. Hence the optimum percentage of fiber content for compressive strength was found to be 0.5%.

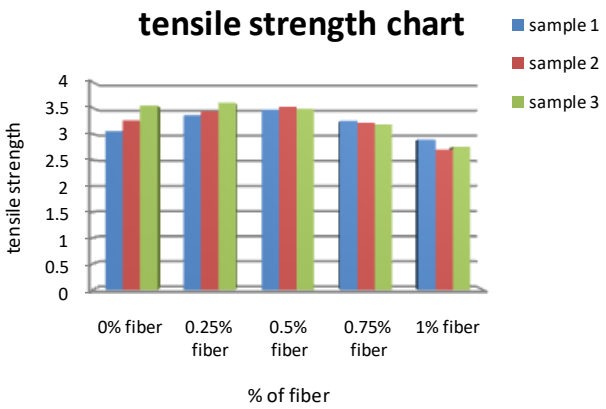
Compressive strength test

fiber percentage up to 0.5% fiber content and then drastically decreases from 0.5% to 1.0% fiber content. Hence the optimum percentage of fiber content for split tensile strength is 0.5%.



Split tensile strength test





B. Splitting tensile strength:

This test was performed on cylindrical specimen reinforced with varying percentages of polypropylene fibers i.e. 0.25%, 0.5%, 0.75% and 1.00%. Tests shall be made at recognized ages of the test specimens, the most usual being 7 and 28 days. Where it may be necessary to obtain the early strengths, tests may be made at the ages of 24 hours ± ½ hour and 72 hours ± 2 hours. The ages shall be calculated from the time of the addition of water to the dry ingredients. At least three specimens, preferably from different batches, shall be made for testing at each selected age. Samples of aggregates for each batch of concrete shall be of the desired grading and shall be in an air-dried condition. The cement samples, on arrival at the laboratory, shall be thoroughly mixed dry either by hand or in a suitable mixer in such a manner as to ensure the greatest possible blending and uniformity in the material.

The results of split tensile strength test shows that the split tensile strength of concrete increases with the increase of

C. Flexural strength:

Flexural Strength of Concrete generally comes into play when a road slab with inadequate sub-grade support is subjected to wheel loads or there are volume changes due to temperature or shrinking.

Concrete beams (size 50cm x 10cm x 10cm) reinforced with varying fiber content i.e. 0.25%, 0.5%, 0.75% and 1.00%. were prepared. Tests shall be made at recognized ages of the test specimens, the most usual being 7 and 28 days. Where it may be necessary to obtain the early strengths, tests may be made at the ages of 24 hours ± ½ hour and 72 hours ± 2 hours. The ages shall be calculated from the time of the addition of water to the dry ingredients. At least three specimens, preferably from different batches, shall be made for testing at each selected age. Test specimen was prepared by filling the concrete into the mould in 3 layers of approximately equal thickness. Each layer was tamped 35

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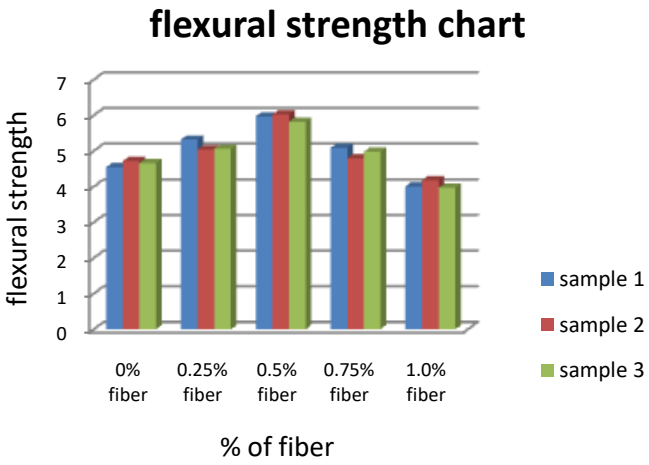
times using the tamping bar of standard specifications. Tamping should be distributed uniformly over the entire cross-section of the beam mould and throughout the depth of each layer. The load was applied at a rate of loading of 400 kg/min for the 15.0 cm specimens and at a rate of 180 kg/min for the 10.0 cm specimens.

The results of flexural strength test shows that the flexural strength of concrete increases with the increase of fiber percentage up to 0.5% fiber content and then drastically decreases from 0.5% to 1.0% fiber content. Hence the optimum percentage of fiber content for flexural strength is 0.5%.



D. Workability:

With the increase in the amount of fiber content, workability of concrete get demoted. During the casting it was observed that concrete with less amount of fiber proved to be more workable than that with higher amount of fiber**.**

V. OPTIMUM FIBER CONTENT

This section focused on the experimental results obtained from each test and analysis of the test results. The experimental tests were carried out to obtain the mechanical properties and behavior of polymer fiber reinforced concrete. The comparisons of mechanical properties and behavior include the workability, compressive strength, tensile strength, flexural strength. Effect of increase in polypropylene fiber percentage by volume of cement was studied. Observation for 28 days curing was recorded and presented in the form of tables and graph. The compressive strength, flexural strength and tensile strength graph were measured and plotted for 28 days. From the observations we found that the optimum percentage of fibers by volume is 0.50%.

VI. CONCLUSION AND RECOMMENDATION

A. Conclusions:

This investigation has evaluated the use of synthetic polymers as reinforcement in concrete construction and concludes that:

1. The addition of polypropylene fibers to concrete may prevent plastic shrinkage cracking, even under severe conditions.

2. Since the low volume fraction of synthetic fibers used in concrete and the low interfacial bond strengths of the fibers do not greatly enhance the flexural strength of the beam, the use of synthetic fibers is not a feasible alternative for primary reinforcement in concrete. Higher percentages of fibers would exceed the cost effective level of 0.1 percent by volume, it is not currently cost effective to use synthetic fibers as primary structural reinforcement for concrete.

3. Adopting higher percentages beyond 0.5% of fiber content deteriorates the workability of concrete**.**

4. From the observations based on laboratory test for compressive strength, split tensile strength and flexural strength of concrete and concrete mixed with synthetic fibers, the following conclusions can be drawn: The maximum compressive strength, split tensile strength and flexure strength of M25 grade of concrete without fiber was observed 32.63MPa, 32.28MPa & 34.64 MPa respectively. The maximum compressive strength obtained was 34.97MPa at 0.5% of fibers and maximum increase in compressive strength was 7.09%. The maximum split tensile strength obtained was 3.58 MPa at 0.5% of fibers and maximum increase in split tensile strength was 9.14%. The maximum flexural strength obtained was 5.94 MPa at 0.5% of fibers and maximum increase in flexural strength was 28.01%. The optimum percentage of fibers for compressive strength, split tensile strength and flexural strength was 0.5%. From the above conclusions, it can be stated that the flexural strength is highly affected due to mixing of synthetic fibers as compared to compressive and tensile strength as the amount of fiber increases in the concrete the tensile strength of the concrete mix decreases after the maximum value due to splitting of concrete.

B. Recommendation:

This study provides the following recommendations for the use of synthetic fiber in SFRC construction:

1. Since plastics lose their tensile properties at 150°C, it is recommended that synthetic fiber reinforcement be used in applications where the maximum ambient temperature is limited to the range of 100°C to 150 °C.
2. Synthetic fiber reinforcement to be used in concrete that will be subjected to prolonged conditions of high humidity should be composed of alkali-resistant synthetic fibers such as polypropylene or polyethylene.
3. Synthetic fibers should be used to prevent plastic shrinking cracking in placements susceptible to this condition.
4. Research should be continued to develop the uses for synthetic fiber-reinforcing material in concrete, especially in

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the use of higher contents of synthetic fibers to prevent drying shrinking cracking, and in the susceptibility of synthetic fiber reinforcement to alkaline hydrolysis and consequent reduction in service life of synthetic fiber-reinforced concrete.

5. Larger percentages beyond 1.0% of fiber contents should be avoided to maintain the workability or use the appropriate admixtures.

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