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Improvement in Tensile Strength of Concrete Using Steel and Polypropylene Fibres

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Abstract:
This paper focuses on the experimental investigation carried out with the fixed dosage of Hooked End Steel fibres along with a combination of two different lengths of Polypropylene fibres i.e. PP fibres i.e. of 6mm length and PP fibres of 12mm length. The mechanical properties such as compressive strength, Split-Tensile Strength and Flexural strength were studied. The main purpose of this study is to find out a suitable and optimum amount of fibre content with a combined effect of two different fibres such that the overall cost gets optimised. The Steel fibres were used with an Aspect Ratio of 80 that is L=60mm and diameter=0.75mm. The Steel fibre was then fixed to a percentage of 1% along with a varying percentage of Polypropylene fibres that too of two different lengths, viz; 6mm and 12 mm with the varying percentages of 0.15%, 0.30 & 0.45%. Results of the experimental study indicate a specific trend of variation in the strengths.

Keywords: Aspect Ratio, Lengths of PP fibres, mechanical properties;

I.INTRODUCTION

Cement concrete is characterized by brittle failure, which is nearly complete loss of loading capacity, once failure is initiated. This characteristic, which limits the application of the material, can be overcome by the inclusion of a small amount of short randomly distributed fibres (steel, glass, synthetic and natural) and can be practiced among others that remedy weaknesses of concrete, such as low growth resistance, high shrinkage cracking, low durability, etc.

We can change the durability and strength of concrete by creating suitable changes in its ingredients like, aggregate, cementitious material and water and by adding some special ingredients. There is no replacement of such a widely used material i.e. concrete which has been discovered by man and there is no second opinion that it is second most widely used material on this planet other than water.

In this study we will try to analyse the behaviour of concrete at some different dosage of the constituent materials making a substance known to us as 'concrete'. For achieving this objective, we will use some fibres which are easily available as well as nature friendly thereby not compromising with the ecology of the system. A number of studies have shown that there is always a significant increase in the strengths of concrete when there is inclusion of natural or artificial fibres. Taking a note of all these studies we have tried to study the effect of adding fibres. The strengths will be dependent upon the extent and the type of fibre we use. These fibres are of various types, available in various lengths, sizes, diameters, aspect ratios, shapes etc. So, adding fibres in concrete can pointedly augment the strengths of concrete. All these fibres have different impacts on the concrete some helps in increasing ductility, while others can improvise on the toughness index of concrete. Recycling has become the need of the hour. Millions of tons of concrete is generated every year as waste throughout the globe. Hence, waste utilization in civil engineering construction has become an attractive alternative for disposal and protecting environment.

II.FIBRES IN CONCRETE

There are number of fibres that are being used in construction industry and these have continuously proved to be the best alternative as we talk about the strength governing parameters of concrete. In this study we have used Steel and Polypropylene fibres and their variations at specific dosages were tested and analysed. Both of these fibres have certain properties as we discuss.

The polypropylene fibres that we used are alkali-resistant, have lower thermal conductivity as compared to any other natural or synthetic fibres. Most importantly, these are Recyclable, ecologically friendly. Incinerates to trace ash with no hazardous volatiles. They are available in various cut lengths for example 6mm, 12mm. Not only this Steel fibres also exhibit properties like these fibres help in bridging the cracks which develop under tension, thus transfer the tension across them during this process. These are induced in concrete during mixing of its constituent materials. It then, hardens with concrete and upon hardening these fibres helps in improving various properties of concrete viz. fracture toughness, ductility, dissipation of energy, impact resistance, limiting of crack propagation and fatigue resistance. Steel fibres are available in different shapes and sizes, viz; hooked-end steel fibres, corrugated steel fibres, straight steel fibres etc.

A. Aspect Ratio

The ratio of length to diameter of fibre is defined as the aspect ratio of fibre. The aspect ratio varies from 30 to 150. We can measure the diameter of fibre with Venire calliper. Mostly the rise in aspect ratio raises the strength and toughness till the aspect ratio of 100. Above that the strength of concrete drops,

in view of decreased workability and condensed compaction. Aspect ratio 80 of steel fibre gives good results.

III. LITERATURE

The fibre reinforcement had no appreciable effect on the flexural strength when the same mix proportions for different quantities of fibres were used. However, when the fibre factor adjustment is made, the flexural strength may increase with increased fibre content. More research is needed to optimize fibre performance at higher fibre volumes. Studies have been made and it has been observed that the fatigue strength, endurance limit, toughness index, impact resistance have been improved but there is no effect in the improvement of tensile strength of concrete, even if a little is observed, the grade of the concrete is not mentioned.

A. Objectives

The main objective of this study is to design concrete of M30 grade using natural constituents as per BIS 10262 and test for its properties. To add 1% steel fibres with an aspect ratio of 80 to concrete design mix impregnated with variable dosage of 6mm & 12mm PP fibres. To study the combined effect of Steel fibres and PP fibres on the properties of concrete.

B. Methodology

The methodology to accomplish this work is illustrated in the following fig.1:

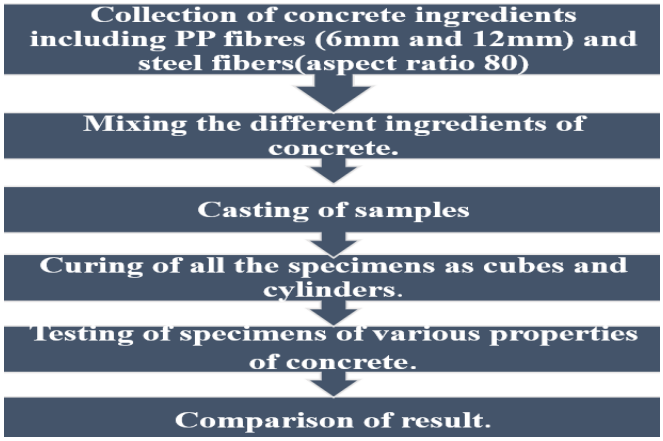

Figure. 1. A flow chart showing the methodology followed

A. Constituent Materials

1) Cement: The cement used in this experimental investigation was ultra-tech OPC 43 grade. Various tests such as consistency test, initial setting time, final setting time, specific gravity test and soundness tests were performed. It was tested as per relevant regulatory norms of IS code (BIS: 8112). The mix proportion was listed in table1.

Table.1. Final mix proportion

Grade	Cement	FA	CA	w/c
M30	1	1.71	3.09	0.40

***2) Fine and Coarse Aggregates*:** In the experimental studies, coarse sand was obtained from the local river bed. Its various physical properties were conformed to IS: 383 – 1970 and as per the recommendations of referred I.S code the material retained on I.S Sieve No.480 (4.75mm) was termed as coarse aggregate. Natural river sand was used as a fine aggregate. Sand having a specific gravity of 2.65, sand was confirmed to zone – III as per IS: 383-1970.The aggregates do not contain any dust particles before they are used in cement. Coarse aggregates of Specific Gravity =2.68 were used.

3) Steel fibre: The fibres that I have used in this study are hooked end Steel Fibre. This shape is probably the most popular and successfully used in earlier structures. Steel fibres are available in various types. The proper details regarding fibres used in the work are given below. These are mixed in concrete as per proportions given in experimental program.

Figure.2 Steel Fibres with Aspect Ratio 80

4) Polypropylene Fibres: Different volume fractions of fibrillated polypropylene fibres (PPF) with lengths 6mm and 12 mm are used. The fibres and their specifications are provided by Reliance Industries Ltd. The name of the fibre is Recron 3s. They are manufactured from film sheets which are cross connected by adequate fibre lengthwise. They are available in various cut lengths. In this work I have used 6mm and 12mm length PPF as shown:

Figure.3. Polypropylene Fibres of 6 mm and 12 mm lengths

5) Water: The potable water used was free from iron, vegetable matter or any other type of substances, which are likely to have adverse effect on concrete or reinforcement.

A. Testing methods

1) Cube Compression Test: This test gives directly compressive strength of concrete. The test was carried out as per the recommendations laid down in BIS: 516.

2) *Split Tensile Test:* The tensile strength is one of the basic properties of the concrete. Split tensile test is being done to determine the split tensile strength of concrete using a cylinder which splits across the vertical diameter. Split tensile strength test of specimen with and without Steel and PP fibres

were carried out as per BIS: 5816. As per IS:456 split tensile strength of concrete = 0.7 $\sqrt{F_{ck}}$

3) ***Flexural Test:*** The flexural tests of beams of size 100 × 100 × 200mm were conducted using a flexure testing machine. The specimen with and without the certain percentage of Steel and PP fibre were placed in the machine in such a way that the load is applied on the upper surface of specimen with two lines 13.3 cm apart. The load on the specimen increases gradually till the specimen breaks down, the maximum load at which the specimen fails is recorded for further analysis.

Figure.4. Crack at the bottom of the beam

B. Effect on Compression Test values of Steel and PP fibre reinforced Concrete

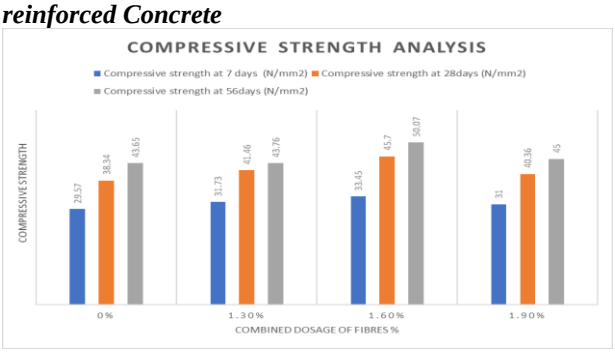

Figure.4. Bar graph showing the variation of compressive strength of Steel and varying PP fibre reinforced concrete.

C. Effect on Split Tensile Strength:

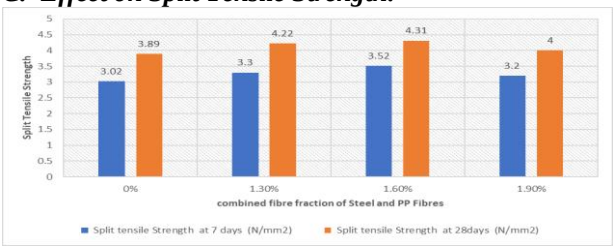

Figure. 5. Bar graph showing the variation of split tensile strength of Steel and varying PP fibre reinforced concrete.

D. Effect on Flexural Test of Beams:

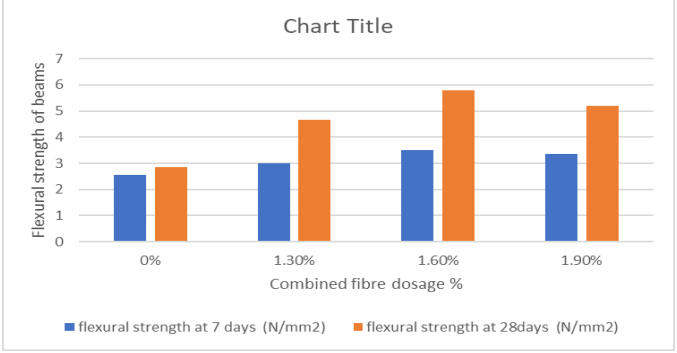

Figure. 6. Bar graph showing the variation of flexural strength of Steel and varying PP fibre reinforced concrete.

E. Results and discussion

As shown in below diagrams that there is a significant increase in the mechanical properties of concrete. According to the experimental work, it has been found out that overall up to 20% the compressive strength of the concrete has been achieved as shown in fig.7. The flexural strength test of concrete beams was performed and the results after 7 and 28 days showed an incremental increase in strength of about 37 and 103 percent respectively for a combined fibre replacement of 1.6%. Also, for split tensile strength test, it has been observed that the maximum increase in the strength was 10 and 16 percent of about 7 and 28 days of curing.

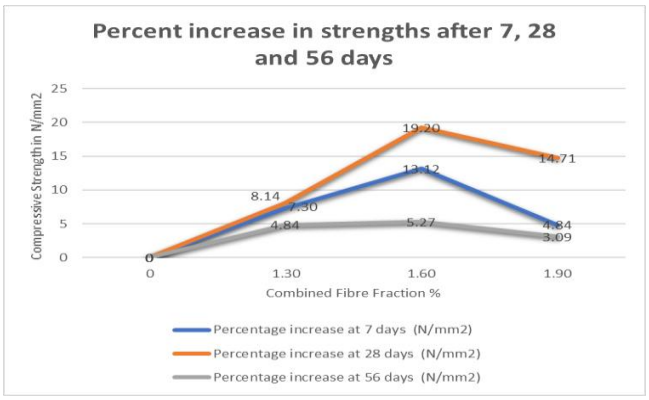

Figure.7. Percent Increase in Compressive Strength after 7, 28, 56 days

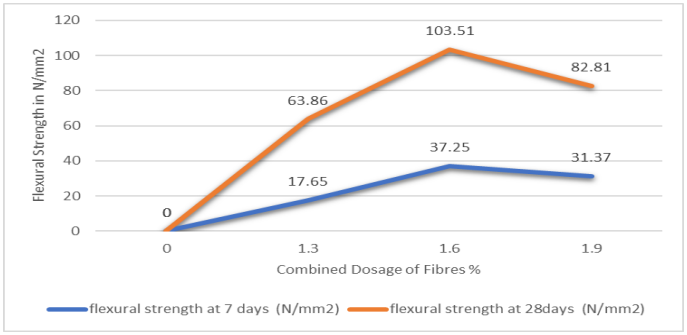

Figure.8. Percent Increase in Flexural Strength after 7 & 28 days

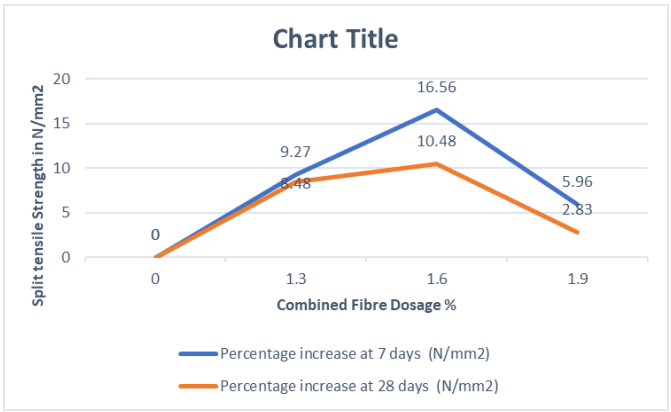

Figure.9. Percent Increase in Split Tensile Strength after 7 & 28 days

IV. CONCLUSIONS

1) *The* With the increase in steel and PP fibre reinforced concrete, the mix becomes less workable. However, the workable mix was achieved at 1.35 and 1.6% replacement. But above this percentage the mix became little harsh.

2) The strength parameters such as compressive strength, split tensile strength, flexural strength showed an increase in their value when steel and PP fibres were added. the increment in strength increased with increase in the percentage of cement with Steel and PP Fibres.

3) However, the strength increment at 0.3% PP1 and 0.3% PP2 was maximum throughout the investigation. The compressive strength at combined dosage of 1.6% was found out to be the maximum and increased up to 20% after 28 days of curing.

4) The increment increase in the percentage of split tensile strength test was found out to be increased up to 11% after 28 days of curing. Thus, replacement of about 1.6% overall for steel and PP fibres.

V. ACKNOWLEDGMENT

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