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RESEARCH ARTICLE

STRENGTH PROPERTIES OF POLYPROPYLENE FIBRE REINFORCED FLY ASH CONCRETE

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ABSTRACT

This study addresses the strength behaviour of polypropylene fibre reinforced fly ash concrete (PFRFAC). The variables of study included the polypropylene fibre content (0.25%, 0.3%, 0.35%, 0.40%, 0.45% and 0.50%) and 10% of Fly ash as cement replacement are incorporated in all the concrete mix proportions considered in this study. The test results indicate that the mechanical properties of concrete increases with 0.40% polypropylene fibre with 10% fly ash content

INTRODUCTION

General

Concrete is widely used in structural engineering with its high compressive strength, low cost and abundant raw material. But common concrete has some shortcomings, for example, low tensile and flexural strength, poor toughness, high brittleness, and so on that restrict its application. To overcome these deficiencies, additional materials are added to improve the performance of concrete. Fibre reinforced concrete is a composite material that has been developed in recent years. It has been successfully used in construction with its excellent flexural tensile strength, permeability and so on. Short fibres have been known and used for centuries to reinforced brittle material like cement or masonry bricks. At that time, fibres were natural fibres, such as horse hair, straw, etc. Now a day's numerous fibre types are available for commercial uses, the basic types begin steel, glass, synthetic materials (polypropylene, carbon, nylon, etc.) and some natural fibres. Fibre-reinforcement is predominantly used for crack control and not structural strengthening. Although the concept of reinforcing brittle materials with fibres is quite old, the recent interest in reinforcing cement-based materials with randomly distributed fibres is quite old; the recent interest in reinforcing cement based materials with randomly distributed fibres is based on research starting in the 1960's. Since then, there have been substantial research and development activities throughout the world. It has been established that the addition of randomly distributed polypropylene fibres to brittle cement based materials can increase their fracture toughness, ductility and impact resistance.

Rana (2011) investigated the effects of polypropylene fibre on the compressive and flexural strength of normal weight concrete**.** Four mixes used polypropylene fibre weight with 0.4, 0.8, 1.0 and 1.5% of cement content. To provide a basis for comparison, reference specimens were cast without polypropylene fibre. The test results showed that the increase of mechanical properties (compressive and flexural strength) resulting from added of polypropylene fibre was relatively high. The increase was about 64 percent for compressive strength, while and in flexural strength was about 55.5 percent.

Parveen (2013) investigated the structural behaviour of fibrous concrete using polypropylene fibre, the aim of the present study is to investigate the effect of variation of polypropylene fibres ranging from 0.1% to 0.4% along with 0.8% steel fibres on the behaviour of fibrous concrete. The mechanical properties of the concrete such as compressive and tensile strength have been investigated. The result shows that addition of polypropylene fibre has a little effect on the compressive strength, but there was significant increase in the tensile strength with increase in fibre volume fraction. The present investigation shows an increase of 47% of split tensile strength and 50% of flexural strength. The result shows that ultimate load mainly depended on percentage volume fraction of fibre.

Murahari (2013) studied the **e**ffects of Polypropylene fibres on the strength properties of fly ash based concrete, the scope of present investigation deals with the strength properties of concrete containing polypropylene fibre, and class C fly ash with different proportions. In this study Various mixture of class C fly ash in ratio of 30%, 40% and 50% was used in the concrete mix containing polypropylene fibre of volume fractions of 0.15,0.20,0.25,0.30 was used for all fly ash concrete mixes.. Each series consists of cubes, cylinders and prisms as per IS standard. A series of tests were carried out to find out the compressive strength, split tensile strength, flexural strength at the age of 28 days. The above said mixtures with Fly ash containing polypropylene fibre in different volume fractions with different water cement ratio were compared in this study. At the age of 28 days each mixture were tested and analysed in order to find out the best efficient mixture in favouring of strength characteristics of concrete mix.

Komal Bedi (2014) studied the eexperimentally for flexure strength on polypropylene fibre reinforced concrete. The main purpose of this paper is to study the effects of polypropylene

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fibre on the flexure strength of concrete. The experimental programmed was under taken to test standard concrete beam of size (150 x150) mm with a span 700 mm for studying strength in flexure. The sample were compared without any fibre and with polypropylenes fibre of intensity 0.89 kg per cum of concrete. To provide a basis for flexure, reference specimens were cast without polypropylene fibre. The test results showed that the mechanical properties of flexural strength resulting from added of polypropylene fibre was relatively high.

This study addresses the strength of polypropylene fibre reinforced fly ash concrete (PFRFAC). The variables of study include the optimation of polypropylene fibre content.

MATERIALS

The testing of the ingredient materials of concrete such as cement, fine aggregate and coarse aggregates are carried out and results are presented below.

Table 1 PFRFAC Properties

Property	Polypropylene Fibre	Advantages
Material	100% virgin synthetic polypropylene fibres	Conforms to IS 456, 2000 Amendment No. 3,August 2007,IRC 44, 2008, IRC SP 46, 2008
Fibre length	12mm	length provides choice of aspect ratio
Dispersion	Excellent	Excellent dispersion in mixtures and superior dispersion in Manual mixing.
SP. Gravity	0.91	Offers homogeneous concrete and mortar mix.
Colour	Brilliant White	It can't be distinguished
Melt Point	160° C	Secures the structures
Alkali Resistance	Very Good	Conforms to the test procedure laid by ICBO AC 32
UV stability	Excellent	Higher UV Resistance ensures longevity.

Table 2 Mix Proportion for Control Concrete

Cement	Fine Aggregate	Coarse Aggregate	Water
425.73kg	615.09kg	1182.42kg	191.58 lit
1	1.44	2.77	0.45

Testing of Cement

The most widely used of the construction cements is Portland cement. It is a bluish-gray powder. Type: Zuari -53 grade ordinary Portland cement conformed to the limits of IS 12269-1987.

Testing of Fine Aggregate

The fine aggregate is passing through 4.75 mm sieve and had a specific gravity of 2.63. The grading zone of fine aggregate is zone III as per Indian Standard specifications. Locally available river sand is used in the experimental investigation. The river sand conformed to the limits of IS 383-1970 when tested.

Testing of Course Aggregate

Coarse aggregate are the crushed stone is used for making concrete. Graded crushed stone usually consists of only one kind of rock and is broken with sharp edges. Machine chorused granite broken stone angular in shape is use as coarse aggregate.

Fly Ash

Class C fly ash generally contains more than 20% lime (CaO). Unlike Class F, self-cementing Class C fly ash does not require an activator. Alkali and sulphate (SO4) contents are generally higher in Class C fly ashes.

Water

In general, ordinary water is considered fit for making Concrete. Water should be free from acids, oils, alkalis, vegetables or other organic impurities. Firstly, it causes a chemical reaction with the cement to form cement paste in which the inert aggregate are held in suspension until the cement paste has hardened. And secondly it acts as a lubricant in the mixture of fine aggregate and cement.

Polypropylene Fibre

Polypropylene (PP) fibres belong to the newest generation of large-scale, manufactured chemical fibres, having the fourth largest volume in production after polyesters, polyamides and acrylics. PP is one of the most successful commodity fibres, reaching a world production capacity of four million tons a year. Due to its low density (0.9gm/cc), high crystalline, high stiffness and excellent chemical/bacterial resistance. Fly ash has a high amount of silica and alumina in a reactive form. These reactive elements complement hydration chemistry of cement.

Hydration chemistry of Cement When cement reacts with water, the hydration of cement begins. On hydration, cement produces C-S-H Gel. This C-S-H Gel binds the aggregates together and strengthens the concrete. However, one more compound is produced on hydration that is so different in behavior. It is none other than the Calcium Hydroxide. In construction industry, it is generally referred to as Free Lime. Aggressive environmental agents like water, sulphates, CO2 attack this free lime leading to deterioration of the concrete.

The PFRFAC properties were presented in Table 2.1.

Experimental Program

Casting of Specimens

The test program was considered the cast and testing of concrete specimens of cube (150 mm) and cylinder (150 x 300 mm). The specimens were cast M30 grade concrete using ordinary Portland cement, Natural River sand and the crushed stone of maximum size 12.5 mm. Each three numbers of specimens were made to take the average value. The specimens were demoulded after 24 hours. The mix proportions of control concrete are presented in Table 3.1.

Testing of Specimen

Testing of specimens was shown in Fig 3.1.

Compressive strength

For each mix, totally nine number of cubes of size150mm were cast and tested using 200T capacity compression Testing Machine (CTM). The specimen was placed on the platform of the compression testing machine. The load was applied gradually until the failure stage. The ultimate load was noted and calculated the compressive strength of corresponding specimen. Test were conducted as per IS 516-1959.

Split Tensile Strength

For each mix, totally nine number of cylinders of size 300 x 600 mm were cast and tested using 100T capacity compression Testing Machine (CTM). The specimen was placed perpendicular to normal axis on the platform of the compression testing machine. The load was applied gradually until the failure stage. The ultimate load was noted and calculated the tensile strength of corresponding specimen.

Flexural Strength

For each mix, totally nine number of prism of size 100 x 100 x 500 mm were cast and tested using 5T capacity Flexural Testing Machine (FTM). The specimen was placed perpendicular to normal axis on the platform of the flexural testing machine. The load was applied gradually until the failure stage. The ultimate load was noted and calculated the flexural strength of corresponding specimen.

RESULTS AND DISCUSSION

The test results of concrete specimens were discussed as below:

Fig. 1 Compression, Split Tensile and Flexural Strength Testing Set ups

Table 3 Compression Test Results

Specimens	Load in Tonne	Compressive Strength N/mm^2
Control	86	38.22
PP 0.25% Fly ash 10%	88	39.11
PP 0.30% Fly ash 10%	91	40.44
PP 0.35% Fly ash 10%	96	42.66
PP 0.40% Fly ash 10%	102	45.33
PP 0.45% Fly ash 10%	98	43.56
PP 0.50 % Fly ash 10%	92	40.88

Compressive Strength

The compressive strength was compared to control specimen with various percentages of Polypropylene Fibre and 10 % of constant fly ash. The compressive strength for PP 0.25% increases in 2.33%, when compared to control specimen. The compressive strength for PP 0.30%, PP 0.35% and PP 0.40% PP 0.45% and PP 0.50% increases in 5.81%, 11.62% and 18.60% respectively, when compared to control specimen. PP 0.45% and PP 0.50% increases in 13.97% and 6.95% respectively, when compared to control specimen. PP 0.40% was higher than the compressive strength compared to all other ratios. The compressive strength and various mix concrete test values are presented in Table 4.1 and variation of compressive strength was shown in Fig.4.1.

Compressive strength

For each mix, totally nine number of cubes of size150mm were cast and tested using 200T capacity compression Testing Machine (CTM). The specimen was placed on the platform of the compression testing machine. The load was applied gradually until the failure stage. The ultimate load was noted and calculated the compressive strength of corresponding specimen. Test were conducted as per IS 516-1959.

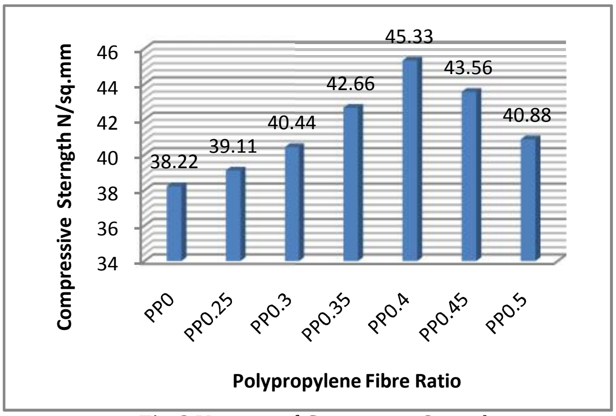

Fig. 2 Variation of Compressive Strength

Split Tensile Strength

For each mix, totally nine number of cylinders of size 300 x 600 mm were cast and tested using 100T capacity compression Testing Machine (CTM). The specimen was placed perpendicular to normal axis on the platform of the compression testing machine. The load was applied gradually until the failure stage. The ultimate load was noted and calculated the tensile strength of corresponding specimen.

Flexural Strength

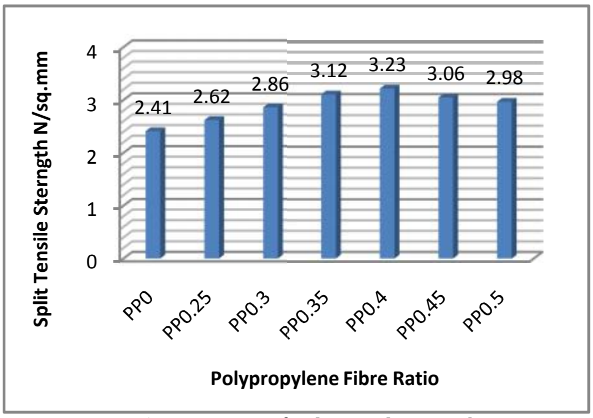

Fig.3 Variation of Split Tensile Strength

For each mix, totally nine number of prism of size 100 x 100 x 500 mm were cast and tested using 5T capacity Flexural Testing Machine (FTM). The specimen was placed perpendicular to normal axis on the platform of the flexural testing machine. The load was applied gradually until the failure stage. The ultimate load was noted and calculated the flexural strength of corresponding specimen.

RESULTS AND DISCUSSION

The test results of concrete specimens were discussed as Below:

Table 4 Split Tensile Test Results

Specimens	Load in Tonne	Tensile Strength N/mm^2
Control	17	2.41
PP 0.25% Fly ash 10%	18.5	2.62
PP 0.30% Fly ash 10%	20.20	2.86
PP 0.35% Fly ash 10%	22.04	3.12
PP 0.40% Fly ash 10%	22.41	3.23
PP 0.45% Fly ash 10%	21.62	3.06
PP 0.50 % Fly ash 10%	21.05	2.98

Table 5 Flexural Strength Test Results

Specimens	Flexural Strength N/mm^2
Control	5.62
PP 0.25% Fly ash 10%	5.83
PP 0.30% Fly ash 10%	6.03
PP 0.35% Fly ash 10%	6.23
PP 0.40% Fly ash 10%	6.73
PP 0.45% Fly ash 10%	6.43
PP 0.50 % Fly ash 10%	6.05

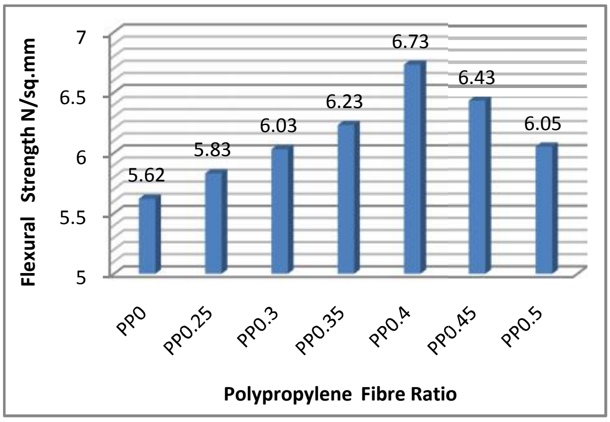

Fig.4 Variation of Flexural Strength

Compressive Strength

The compressive strength was compared to control specimen with various percentages of Polypropylene Fibre and 10 % of constant fly ash. The compressive strength for PP 0.25% increases in 2.33%, when compared to control specimen. The compressive strength for PP 0.30%, PP 0.35% and PP 0.40% PP 0.45% and PP 0.50% increases in 5.81%, 11.62% and 18.60% respectively, when compared to control specimen. PP 0.45% and PP 0.50% increases in 13.97% and 6.95% respectively, when compared to control specimen. PP 0.40% was higher than the compressive strength compared to all other ratios. The compressive strength and various mix concrete test values are presented in Table 4.1 and variation of compressive strength was shown in Fig.4.1.

Split Tensile Strength

The split tensile strength was compared to control specimen with various percentages of Polypropylene fibre and 10 % of constant fly ash. The split tensile strength for PP 0.25% increases in 8.71%, when compared to control specimen. The split tensile strength for PP 0.30%, PP 0.35% and PP 0.40% increases in 18.67%, 29.46% and 34.02% respectively, when compared to control specimen. PP 0.45% and PP 0.50% increases in 26.97% and 23.65% respectively, when compared to control specimen. PP 0.40% was higher than the tensile Strength compared to all other ratios. The split tensile strength and various mix concrete test values are presented in Table 4.2 and variation of compressive strength was shown in Fig.4.2.

Flexural Strength

The flexural strength was compared to control specimen with various percentages of Polypropylene fibre and 10 % of constant fly ash. The flexural strength for PP 0.25% increases in 3.73%, when compared to control specimen. The flexural strength for PP 0.30%, PP 0.35% and PP 0.40% increases in 7.29%, 10.85% and 21.30% respectively, when compared to control specimen. PP 0.45% and PP 0.50% increases in 14.41% and 7.65% respectively, when compared to control specimen. PP 0.40% was higher than the flexural strength compared to all other ratios. The flexural strength and various mix concrete test values are presented in Table 4.3 and variation of compressive strength was shown in Fig.4.3.

CONCLUSIONS

From the present investigation on the effect of partial replacement of cement with fly ash and addition of polypropylene fibre concrete, the following conclusions were drawn:

- 0.40% polypropylene fibre concrete is superior to all other mixes.
- The compressive strength increases in 45.33N/ mm^2 for 0.40% polypropylene fibre concrete, when compared to the control concrete.
- The tensile strength increases in 3.23 N/ mm^2 for 0.40% polypropylene fibre concrete, when compared to the control concrete.
- The flexural strength increases in 6.73 N/ mm^2 for 0.40% polypropylene fibre concrete, when compared to the control concrete.

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