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Flexural Behavior of Self-Compacting Concrete Reinforced with Polypropylene Fibers

S. N. Patil[1], Prachi Chougale[2], Priyanka Khade[3], Rohini Sarnaik[4]
Faculty[1], Student[2, 3, 4]
Department of Civil Engineering
Sanjay Ghodawat Polytecnic, Atigre, Kolhapur, India

Abstract:
Concrete made with Portland cement has certain appearances: it is relatively durable in· compression but weak in tension and tends to be weak. These two weaknesses have limited its use. Another Fundamental weakness of concrete is that cracks start to form as soon as concrete is placed and before it has properly toughened. These cracks are major cause of weakness in concrete mainly in large onsite presents leading to subsequent fracture and failure and general lack of durability. The weakness in tension can be overcome by the use of conventional rod reinforcement and to some Extent by the inclusion of a sufficient volume of certain fibers. Polypropylene is a synthetic hydrocarbon polymer, the fiber of which is made using extrusion processes by hot drawing the material through a die. Its use enables reliable and effective utilization of intrinsic tensile and flexural strength of the material along with significant reduction of plastic shrinkage cracking and minimizing of thermal cracking. The paper deals with the effects of addition of various proportions of polypropylene fiber on the properties of concrete. An experimental program was carried out to explore its effects on flexure test on concrete

Keywords: Polypropylene fibers, hydrocarbon Polymer

1. INTRODUCTION

Concrete being the most popularly used building material, many efforts were made to improve the qualities of concrete. Concrete being extremely week in tension, its tensile capacity can be increased either by introducing steel rods in the tension zone or by uniformly distributing the fibers (metallic or mineral or natural) in the concrete mass. Reinforcing brittle matrices to improve their mechanical properties is an age-old concept. However, the modern development of fiber reinforced cement composites dates back only to the 1960s. In the beginning, only straight steel fibers were used. The acceptance of fiber reinforced concrete by the construction industry has lead to a number of developments. Among these developments are new fiber types made of steel, stainless steel, polymeric and mineral materials, and naturally occurring materials. New manufacturing techniques and applications have also been developed. A large number of researchers around the world have investigated the various aspects of fiber-reinforced composites. The introduction of fibers into the concrete induces many desirable properties. Additions of fibers increase the ductility of concrete and substantially improve the tensile strength, cracking resistance, impact strength, wear and tear and fatigue resistance. Many types of fibers like steel, carbon, GI, glass, asbestos, nylon, polypropylene, polyester, jute, coir fibers etc., can be used for the production of fiber reinforced concrete. The uses of short fibers in structural concrete alter the mechanical properties of the concrete. It shows that effects of different types, geometry and shape of short fibers may involve and varies workability, compression resistant, tensile strength, flexural behavior, elasticity and especially the post cracking behavior such as ductility and energy absorption capacity. A limitation of concrete Plain concrete possesses two major drawbacks as a structural material. They behave in a brittle or semi brittle fashion and possess a very low tensile strength. Micro cracks develop in the material during its manufacture due to inherent volumetric and micro structural changes, and an essential discontinuous, heterogeneous system thus exists even before any external load is applied. In addition to the low tensile strength, the material possesses little resistance to tensile crack propagation and this in turn results in a low fracture toughness and limited resistance to impact and explosive loading. The successful use of the material in construction, therefore, depends in restricting the stresses in the material under working load condition, and cracking and deformation further limit the exploitation of the material. It is necessary, therefore, to impart tensile resistance properties to a concrete structural member in order to use it as a load bearing material. This has been achieved since a hundred years or more, by the use of reinforcing bars. Reinforcement with iron bars enables concrete to carry tensile stresses quite successfully but the cracking strain of concrete is still so low that it cracks long before the wire is seriously loaded, and if a larger tensile load is put upon the combined system an elaborate pattern of cracks appears in the concrete. In conventional concrete reinforcement, the cracks are a great disadvantage since if small, they let water in and the iron is attacked, if large, the concrete falls out in pieces. To avoid these difficulties, one thing to do is to put the concrete permanently into compression, by putting the steel reinforcement permanently in tension. This is nothing but the method of prestressing. Although both these methods provide tensile strength to the concrete members, they do not increase the inherent tensile strength of concrete itself. Thus, the overall performance of the traditional reinforced concrete composite material is still effectively dictated by the individual performance of the concrete phase and the steel phase. This has led to the search for new materials-particularly two phase composites-in which the weak matrix is reinforced with strong stiff fibers to produce a composite of superior properties and performance. It has been found that the addition of small closely spaced and uniformly dispersed fibers to concrete would act as crack arrestors and would substantially improve the tensile strength and other properties of concrete. This type of concrete is called as Fiber Reinforced Concrete.

2. EXPERIMENTAL PROGRAM

2.1 Preliminary investigation:

It includes physical analysis such as specific gravity, sieve analysis, density etc. and to determine whether the aggregates and cement are according to standards which we are using.

1.5 Experimental investigation:

The Experimental program was designed to investigate admixture as partial replacement of cement along with polypropylene fiber in concrete. The replacement levels of cement by admixture are selected as 1% and for various proportions & of polypropylene fiber are 0%, 0.25%, 0.5%.
The specimens of standards cube [150 x 150 x 150] & specimens of standard beam (500 x 100 x 100) to be casted by using polypropylene fiber and compressive strength , this determined after 3, 7, 14 & 28 days. To cast the cylinder and tensile strength is determined after 3, 7, 14 & 28 days. To casting the Beams and flexural strength is determined after 3, 7, 14 & 28 days.

3. LITERATURE REVIEW

This chapter presents the review of studies conducted on the history, performance and behavior of FRC and the properties of different percentage fiber used that affect the performance of the element. The studies taken for study.

1. Concrete proportioning and testing for self-compatibility

The final stage in the application of the rheological paste mode lfor the design of plain and fiber-reinforced self-compacting concretes consists in combining a cement paste with given rheological properties with the particles of solid skeleton, suitably graded according the chosen optimum criterion. At this stage the paste volume ratio becomes another variable in the mix-design procedure. The paste volume ratio governs the average spacing between solid particles and, as a consequence, the required rheological properties of the paste to obtain a concrete with the desired flow ability and stability characteristics. In the present work, for plain concrete the following paste volume ratios have been employed: Vp = 0.32, 0.36 and 0.40. They correspond, for solid skeleton graded as in Fig. 6 (coarse/fine ratio=0.815; void ratio=21.94%), to an average aggregate spacing respectively equal to 0.272, 0.360 and 0.459mm. For fibre-reinforced mixes in order to keep, for the sake of consistency, the same values of average aggregate spacing, the slightly different measured void ratio led to consequently modified paste volumes (see Tables 5 and 6, for the solid skeleton grading). (Liberato Ferrara, et al 2007)

2 Workability of fresh concrete with micro fibers –

It is impossible to investigate the flow behaviour of fresh SCHPC with macro fibres using a flow-channel due to the small diameter of funnel outlet. Furthermore, it has observed in the practice that the steel reinforcement can block the flow of fresh fibre - reinforced concrete and has strong influence both on the flow ability and on the segregation behaviour. (Y. Ding S. Liu , et al 2007).

3 Materials-

The materials used in the composition of the SFRSCC, were: cement (C) CEM 42.5R, limestone filler (LF), super plasticizer (SP) of third generation based opolycarboxilates (Glenium® 77SCC), water (W), three types of aggregates (fine river sand, FS, coarse river sand, CS, and crushed granite 5–12 mm, CA) andDRAMIX® RC-80/60-BN hooked end steel fibres (length, lf, of 60 mm, diameter, df, of 0.75 mm, aspect ratio, lf/df, of 80, and yield stress of 1100 MPa). The method used to define the SFRSCC composition, the mixing procedure and other properties of the SFRSCC in the fresh state can be found elsewhere [12]. (V.M.C.F. Cunha , et al 2013)

4 MATERIALS AND MIX PROPORTIONS –

Cement used in this study was ordinary Portland cement which conforms to (ASTM Type I) and (BS EN 197 CEM I). Silica fume was used as mineral additive; it has a specific gravity of 2.2, and a specific surface of 152,000 cm2/gm (according to manufacturer data sheet). The coarse aggregate was natural crushed stone from Ras Al Khaima of nominal size of 10 mm (3/8 in.), a specific gravity of 2.65, and absorption% of 1.3%. The coarse aggregate is washed and left to be air dried to saturated surface dry condition before being used. Two types of sand were used in the study; crushed natural stone sand from Ras Al Khaima with fineness modulus of 3.5 and specific gravity of 2.63, and dune sand from Al Ain area with fineness modulus of 0.88 and specific gravity of 2.63. A modified polycarboxylic ether super plasticizer is used in the study (GELINUM SKY 512_); it complies with ASTM C 494 Types F and G, and ASTM C1017 Types I and II. The admixture is light-brown in colour, with a specific gravity of 1.1, pH value 5–8 and alkali content as Na2O equivalent of 0.26% (according to manufacturer data sheet (Amr S and El-Dieb 2009)

5 CONCRETE MIXTURE –

The constituent materials used in the composition of the SFRSCC were: Portland cement CEM 42.5 R (C), water (W), super plasticizer Sika® 3005 (SP), limestone filler, crushed granite aggregate, fine sand and coarse sand, and hooked-end steel fibres (length, lf, of 30 diameter, df, of 0.55 mm; aspect ratio, lf/df, of 60 and a yield stress of 1100 MPa). The adopted mix proportions are shown in Table 1, where W/C is the water/cement ratio. To evaluate the properties of SFRSCC in the fresh state, the inverted Abrams cone slump test was performed according to EFNARC recommendations [16]. An average spread of 670 mm was achieved without sign of segregation of the constituents. The compressive strength and Young's modulus were determined using cylinders of 150 mm diameter and 300 mm height after 28 days of moist curing in a climate chamber (3 cylinders for each test). The average compressive strength (fcm) and the average value of the Young's modulus (Ecm) were 47.77 MPa (7.45%) and 34.15 GPa (0.21%), respectively, where the values in parentheses represent the coefficient of variation. (Amin Abrishambaf , et al 2013)

6. EXPERIMENTAL RESULTS AND DISCUSSION –

Fresh concrete test - Findings of the fresh concrete assessments show adverse effects of fibers and nanosilica on rheological properties of SCC. Since nano-silica has large effective surface, it absorbs too much water and thus reduces concrete's workability. This would also increase the concrete's shear strength against flow ability viscosity of SCC. This property of nanosilica can be attributed to its high pozzolanoic activity. Results of these assessments are presented in Figs 4–6. As it can be seen from these figures, the higher the percentage of fibres, the lower the workability of the oncrete are resulted. The rate of this reduction in the higher values of fibers percentage was very higher. But the reduction is acceptable based on the limitations of the regulations. Additionally, not in any of the sample, was detected any sign of aggregates–cement matrix separation. Especially in the mixes containg in polypropylene fibre, presence of fibreb improved their stability compared with the reference sample. (Morteza H. Beigi a, et al 2013)

4. OBJECTIVES OF PAPER

1. Collect historical data.
2. To select material used for paper.
3. Design the mix concrete proportion to
4. Achieve the required strength.
5. Carried out laboratory test.
6. Calculate the result obtained by test.
7. Prepare the graphs as per the result.

5. METHODOLOGY

For carrying out proposed work following methodology will adopted.

1. Collection of relevant research data from national and interaction journals, Technical magazines, Reference book and through internet.
2. Selection of suitable ingredient materials required for producing Concrete, including cement, Foundry sand, aggregates and water
3. Determine the relative quantities of these materials in order to produce Concrete mixes.
4. Performing flexural test 3, 7, 14, 28 days and collecting suitable data.
5. Result and Discussion/Conclusion

6 MIX DESIGN

6.1 General

The constituent materials used for FRC are cement, Fine aggregate, coarse aggregate, water, admixtures and fibres. The water cement ratio is the primary controlling variable for compressive strength. The other major variables that control strength and workability are cement content, maximum aggregate size and gradation (size distribution) and the presence of entrained air.

In FRC the major variables controlling workability are the fibre content and the fibre aspect (length to diameter) ratio. The objective is to obtain a mix that produces the required (compressive) strength, is workable and contains a minimum amount of cement. Since cement is the most expensive component in plain concrete. Reduction of cement usually results in better economy.

Calculation of mix design –

Material received at laboratory & considerations:
i) Cement: - Ultrtatech 43 OPC Year = 2018
ii) Sand: - Crushed sand
iii) Metal:- 12mm - 20mm Mixed (50%each).
iv) Water: - Potable water.
v) Admixture : - Chemical

Machinery should present at working place:- Concrete Mixer 10/7 cft, Needle Vibrator, Weigh Batcher, Water measuring device. Curing provision (Gunny bags, etc.) other Device to be maintained: Slump Cone, Cube moulds, Tamping rod 16mm bullet ended. Supervision staff (should present at site):- For Technical purpose - Site Engineer
For checking weight or volume of aggregate & water – Supervisor For checking proper placing & compaction of concrete- Technical assistant.

No. of Cubes to be taken from testing of concrete (for 28 day’s test):-

Up to 5Cum (@ 180 cft) :- 3 (1 sample)
6-15 Cum (@ 530 cft) :- 6 (2 samples)
16-30 Cum (@1060 cft :- 9 (3 samples)
31-50cum (@1765 cft) :- 12 (4 samples)
Above 50 Cum:-12 + 3 for each 50 cum and part thereof (4 + 1 sample)
Referring Through these data and test reports of aggregates, the solution suggested thereon,

6.2 Why Test Flexural Strength?

Designers of pavements use a theory based on flexural strength. Therefore, laboratory mix design based on flexural strength tests may be required, or a cementations material content may be selected from past experience to obtain the needed design MR. Some also use MR for field control and acceptance of pavements. Very few use flexural testing for structural concrete. Agencies not using flexural strength for field control generally find the use of compressive strength convenient and reliable to judge the quality of the concrete as delivered

6.3. Result and Discussion –

The main aim of the investigation program is first to prepare the strength of concrete of grade M30 with locally available ingredient and then to study the effect of different proportion of Polypropylene fibre in the mix and to find comparison of Polypropylene fibre content is 0.0%,0.25%,0.5% in the mix.

The concrete specimens were tested at different age level for mechanical properties of concrete, namely, cube compressive strength, workability of concrete, flexural strength and other test were conducted for cement, chemical admixture, coarse aggregate & fine aggregate. This chapter represents results on workability, cube compressive strength, flexural strength and graphical comparison of polypropylene fibre reinforced concrete with normal concrete mix.

4.2 Details of casting and results:

The test specimens are casted by using a concrete mix with a proportion of 1:1.5:2 with w/c ratio 0.55 along with high range water reducing chemical compound brand name “ADDMIXTM 389.” The polypropylene is varied from 0 to 0.15% respectively.

The detailed proportion has been tabulated. To attain the aim of present study experimental investigation is carried out on 36 Nos. of fibre based reinforced concrete cubes, 36 Nos. of fibre based reinforced concrete beams, having overall dimensions (L x B x H) as 500 x 100 x 100 mm for beam & having overall dimensions (L x B x D) as 150 x 150 x 150 mm for cubes

6.4 Flexural test result –

6.4.1 Test results and discussion-

Following table shows the result after test

Fiber %	3 days	Average %	7 days	Average %	14 days	Average %	28 days	Average %
N 0%	2.6	2.6	4	4.2	4.6	4.6	5.1	5.2
	2.6		4.3		4.6		5.3	
	2.6		4.1		4.5		5.1	
0.25%	4.2	4.3	4.2	4.3	4.6	4.7	4.9	4.9
	4.4		4.4		4.8		4.9	
	4.3		4.4		4.8		4.8	
0.50%	3.5	3.5	4.5	4.6	4.3	4.3	4.9	4.7
	3.5		4.8		4.3		4.7	
	3.5		4.6		4.3		4.5	

3.1 Flexural Strength Graphs: (in KN)

Following bar chart shows the result after test

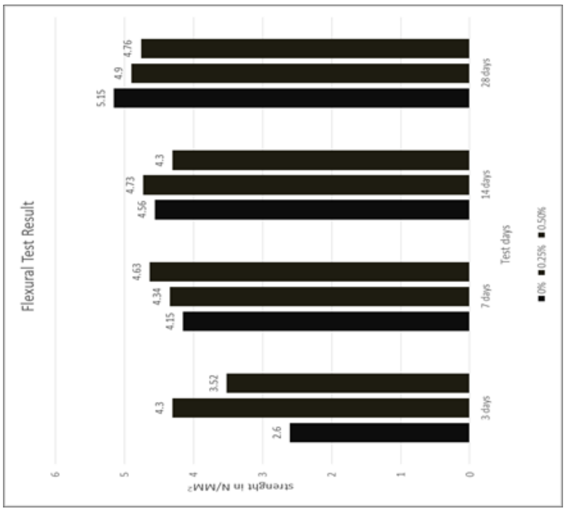

Figure.4.1. Analysis of Flexural Test Result

6.5 Design of Paper:

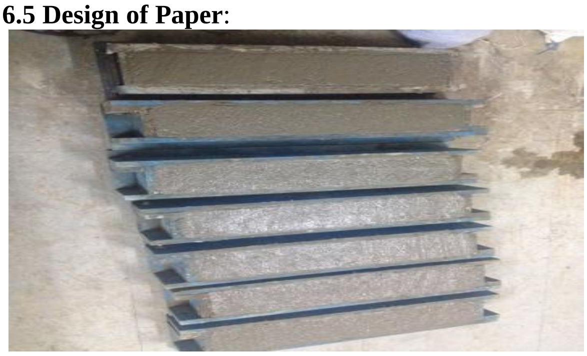

Figure.1. Concrete beam casting

Figure.2. Concrete beam curing

Figure.3. Flexural tests conducted in lab

6.6 Conclusion-

The study on structural behaviour of Polypropylene fibres with different cut length can still be a promising work as there is always a need to overcome the problem of brittleness of concrete. In this study various mixture of polypropylene fibre was used in the concrete mix containing volume fractions of 0.25 & 0.5 was used for all concrete mixes. Each series consists of cubes and beams as per IS standard. A series of tests were carried out to find out the compressive strength, flexural strength at the age of 3,7,14 and 28 days.

They conclude that:-

1. The addition of polypropylene fibres increase the flexural stregth of the concrete mixture and also varying with percentage of polypropylene fibres increases as shown in Fig. No. 4.1
2. The addition of polypropylene fibres at low values actually increases the 28 days compressive strengte but when the volume get higher, then the compressive strength increase.
3. Flexural test of concrete gradually increases with the addition of polypropylene fibr. There is increase in flexural strength as compared with normal plain concrete.
4. As the percentage of polypropylene fibre increases, the strength of concrete also increases. Also aspect ratio of polypropylene increase, the flexural strength of polypropylene concrete increases.
5. The type of Polypropylene affects much the post-peak behaviour of SCC. The deflection-hardening response was observed in case of SCC reinforced with hooked end Polypropylene fibres.
6. The fracture energy increases with the increase of fiber dosage and is higher for hooked end Polypropylene than for straight ones.
7. Increase in post-peak parameters obtained for deflection higher than 2 mm.

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