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Experimental Study on Polypropylene Fiber Reinforced Self Compacting Concrete

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Abstract : Self compacting concrete (SCC) was first developed in 1988 in Japan to achieve durable concrete structures. Conventional concrete tends to present a problem with regard to adequate consolidation in thin sections or areas of congested reinforcement, which leads to a large volume of entrapped air voids and compromises the strength and durability of the concrete Self-compacting concrete (SCC) can eliminate the problem, since it was designed to consolidate under its own mass. This paper experimental study on mechanical performance of polypropylene fiber reinforced concrete (PFRC) under compression, split tensile and flexural loading. The cube compressive strength, cylinder split tensile strength and prism flexural strength of polypropylene fiber reinforced concrete was determined in the laboratory. The M30 grades of concrete mixes and polypropylene fibers of length 30 mm at volume fractions of 0.5%. 1.0%, 1.5% and 2.0%were used in the research. All specimens were tested at curing age of 7^{th} and 28^{th} days.

Keywords : Polypropylene fiber, mechanical properties, self compacting concrete.

Introduction

1.1 General

Self-compacting concrete (SCC) is an innovative concrete that does not require vibration for placing and compaction. It is able to flow under its own weight, completely filling formwork and achieving full compaction, even in the presence of congested reinforcement. SCC was developed first in Japan in the late 1980s to be mainly used for highly congested reinforced structures in seismic regions. After the development of SCC in Japan 1988, whole Europe started working on this unique noise free revolution in the field of construction industry. The last half of decade1991-2000 has remained very active in the field of research in SCC in Europe. That is why, Europe has gone ahead of USA in publishing specifications and guidelines for self compacting concrete (EFNARC2002).

SCC can be defined as an engineered material consisting of cement, aggregate, water, filler, and chemical admixture to take care of specific requirements such as, high flowability, passingability, adequate viscosity and segregation resistance. In the fresh state, this type of concrete should be able to flow, spread and consolidate under its own weight. SCC is a brittle material with low strain capacity. Reinforcement of self compacting concrete with short randomly distributed fibers can address some of the concerns related to SCC brittleness and poor resistance to crack growth. Fibers used as reinforcement, can be effective in arresting cracks both at micro and macro levels.

1.1.1 Fiber Reiinforced Self-Compacting Concrete

Fiber reinforced concrete (FRC) can be explained as a concrete that contains spread at random oriented materials. Normal concrete is brittle under tensile loading and mechanical characteristics of concrete might be enhanced by at random oriented discrete materials which prevent or control initiation, propagation or coalescences of crack. FRC is extremely cement based composite material strengthened with discrete, usually at random distributed fibers. Fibers of numerous shapes and dimensions created from steel, synthetic, glass and natural materials can be used. Fibers mainly improves the post-cracking properties of concrete and gains in a more ductile material behavior. The fibers used were fine polypropylene monofilaments. In the present investigation 30mm fiber length is used. These fibers are manufactured using conventional melt spinning. Polypropylene fibers are thermo plastics produced from Propylene gas. Polypropylene is reasonably economical and when uncolored appears translucent. Polypropylene fibers are Non-Magnetic, rust free, Alkali resistant, safe and easy to use.

1.1.2 Need For Polyprolylene Fibers In Concrete

Concrete develops micro cracks with curing and these cracks propagate rapidly under applied stress resulting in low tensile strength of concrete. Hence addition of fibers improves the strength of concrete and these problems can be overcome by use of Polypropylene fibers in concrete. Application of polypropylene fibers provides strength to the concrete while the matrix protects the fibers.

1.1.3 Production of SCC

a) Powder type self compacting concrete: This is proportion to give the required selfcompatibility by reducing by reducing the water-powder (material < 0.1mm) ratio and provide adequate segregation resistance. Superplasticizers and air entraining admixtures give the required deformability.

b) Viscosity agent type self compacting concrete: This type is proportioned to provideself compaction by the use of a viscosity modifying admixture to provide segregation resistance. Superplasticizers and air entrainment admixtures are used for obtaining the desired deformability.

c) Combination type self compacting concrete: This type is proportioned so as toobtain self compatibility mainly by reducing the water powder ratio, as in the powder type, and a viscosity modifying admixture is added to reduce the quality of fluctuation of the fresh concrete due to the variation of the surface moisture content of the aggregates and their gradations during the production.

1.1.4 Characteristics of SCC

a) Filling ability: The ability of SCC to flow into and fill completely all spaces withinthe formwork, under its own weight, maintaining homogeneity in both vertical and horizontal directions are essential.

b) Passing ability: SCC is passing through congested areas of formwork even closelyspaced reinforcement without blocking caused by interlocking or segregation.

c) Resistance to segregation: The mix has to maintain homogeneity throughout mixing,transporting and casting. The dynamic stability refers to the resistances to segregation during placement. The static stability refers to resistance to bleeding, segregation and surface settlement after casting.

1.1.5 ADVANTAGE OF SCC

- Reducing the construction time and labour cost
- Reducing the noise pollution
- Eliminating the need of vibration
- Improving the filling capacity of congested structural members
- Improved concrete surface

1.1.6 Application

SCC may be used in pre-cast applications or for concrete placed on site. It can be manufactured in a site batching plant or in a ready mix concrete plant and delivered to site by truck. It can then be placed either by pumping or pouring into horizontal or vertical structures. SCC has made it possible to cast concrete structures of a quality that was not possible with the existing concrete technology.

1.2 Objective

The aim of experiment is to study the harden properties i.e. compressive strength, split tensile strength and flexural strength of fiber reinforced self compacting concrete.

Materials

2.1 Collection of Raw Materials

Cement, Fine aggregate, Coarse aggregate, polypropylene fiber, super plasticizer are the various materials used in this project, and collected from local area. Before casting the specimen various test were conducted.

2.2 Cement

Ordinary Portland cement of 53 grade conforming to Indian Standard IS 12269-1987 was used in the experimental program.

2.3 Fine Aggregate

Fine aggregate (sand) used for this entire investigation for concrete was river sand conforming to zone-II of IS 383- 1970 and it was well graded, passing through 4.75mm sieve. The sand was air dried and sieved to remove any foreign material, prior to mixing. The purpose of fine aggregate is to fill the voids in the coarse aggregate and to act as a workability agent

2.4 Coarse Aggregate

Building durable structures and pavements requires use of high quality aggregates or mixture of sand, gravel and crushed rock. These are often obtained from local suppliers of natural rock. These materials help the concrete to bear load that it resist. The size of aggregate used is 12mm.

2.5 Water

The water is used in concrete plays an important part in the mixing, laying compaction setting and hardening of concrete. The strength of concrete directly depends on the quantity and quality of water is used in the mix.

2.6 Polypropylene Fibre

Polypropylene fiber (short-cut strands of very fine denier monofilament*) is added to the concrete during batching. Thousands of individual fibers are then evenly dispersed throughout the concrete during the mixing process creating a matrix-like structure.

2.7 Chemical Admixture

ViscoCrete 20 HE is a third generation superplasticiser specifically designed for the production of soft plastic concrete with very high early strength characteristics. The special formulation of ViscoCrete 20 HE optimizes the dispersion of the binder and at the same time improves the concrete consistency and cohesion.

3.1 Mix Design

Concrete mix design is the method of proportioning of ingredients of concrete to enhance its properties during plastic stage as well as during hardened stage, as well as to find economical mix proportions. There is no standard method for SCC mix design. In this study, Nan Su Method is used for mix design.. Further information on mix design and on methods of evaluating the properties of SCC can be found in the EFNARC Guidelines for SCC

Results and Discussion

4.1 Fresh Concrete Results

Workability of self-compacting concrete can be characterized by three parameters- filling ability, passing ability and resistance to segregation. The fresh properties of concrete are assessed by doing the following experiments such as slump flow test, L-box test, U-box test and V-funnel test. The results for various additions of steel fibers are tabulated below.

4.2compressive Strength

Table gives the test results of compressive strength at 7th and 28th day with various percentages of fibers. Compressive strength increases with increasing percentage of fibers. 0.15% addition of fibers into the concrete shows maximum benefits in compressive strength.

3 Split Tensile Strength

Table gives the test results of flexural strength at 28 days. Tensile strength increases with increasing percentage of fibers. 0.15% addition of fibers into the concrete shows maximum benefits in tensile strength.

4.4 Flexural Strength

Table gives the test results of flexural strength at 28 days. Flexural strength increases with increasing percentage of fibers. 0.15% addition of fibers into the concrete shows maximum benefits in flexural strength.

Table 2.1 Properties Of Cement

S. No	Properties	Test Results
1	Normal consistency	30.5%
2	Specific gravity	3.15
3	Setting time Initial setting Final setting	25 min 260 min

Table 2.2 Properties Of Fine Aggregate

S. No	Properties	Test Results
1	Specific gravity	2.63
2	Loose bulk density	1318.18

S. No	Properties	Test Results
1	Specific gravity	2.7
2	Loose bulk density	1404.2

Table 3.1 Mix Proportions

Ingredients	Mix 1 Kg/m^3	Mix 2 Kg/m^3	Mix 3 Kg/m^3	Mix 4 Kg/m^3
Cement	405.6	405.6	405.6	405.6
FA	833.74	833.74	833.74	833.74
CA	726.67	726.67	726.67	726.67
PP fiber	0.8	0.16	0.32	0.64
Sp	4.056	4.056	4.056	4.056
Water	170.76	170.76	170.76	170.76

Table 4.1 Fresh Concrete Test Results

% OF FIBER	T_{50cm} SLUMP FLOW (sec)	SLUMP FLOW (mm)	L-BOX (H_2/H_1)	V-FUNNEL (sec)	U-BOX (mm)
0	2	750	0.95	6	28
0.5	2	740	0.95	6	27
1	3	730	0.90	8	26
1.5	3	720	0.85	9	24
2	4	700	0.80	11	22

Table 4.2 Compressive Strength

Compressive strength (N/mm^2)		
% of fiber	**7th day**	**28th day**
0	22.6	36.0
0.5	21.2	35.5
1.0	23.1	36.9
1.5	26.2	38.6
2.0	24.0	37.7

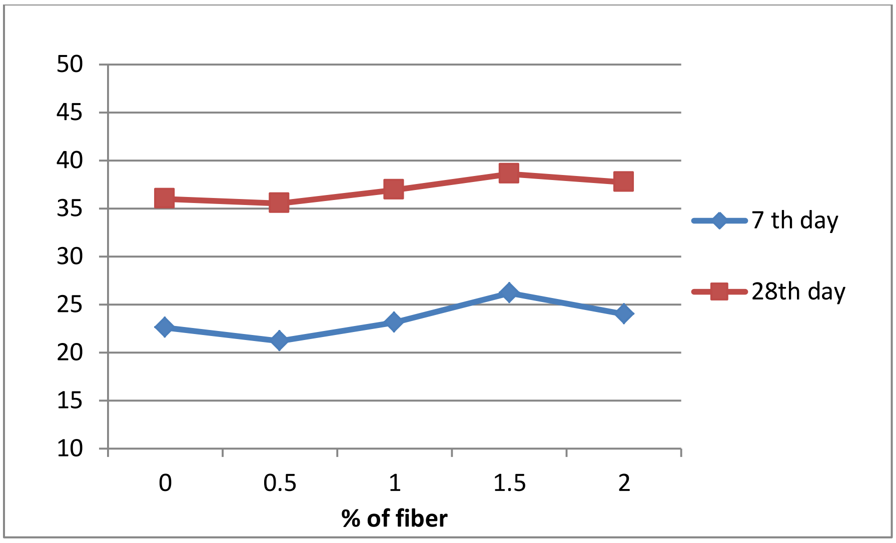

Fig 4.1 Graph showing compressive strength results

Table 4.3 Tensile Strength

Tensile Strength (N/mm^2)		
% of fiber	**7th day**	**28th day**
0	2.00	3.8
0.5	2.26	4.02
1.0	2.47	5.20
1.5	3.10	6.08
2.0	2.60	5.70

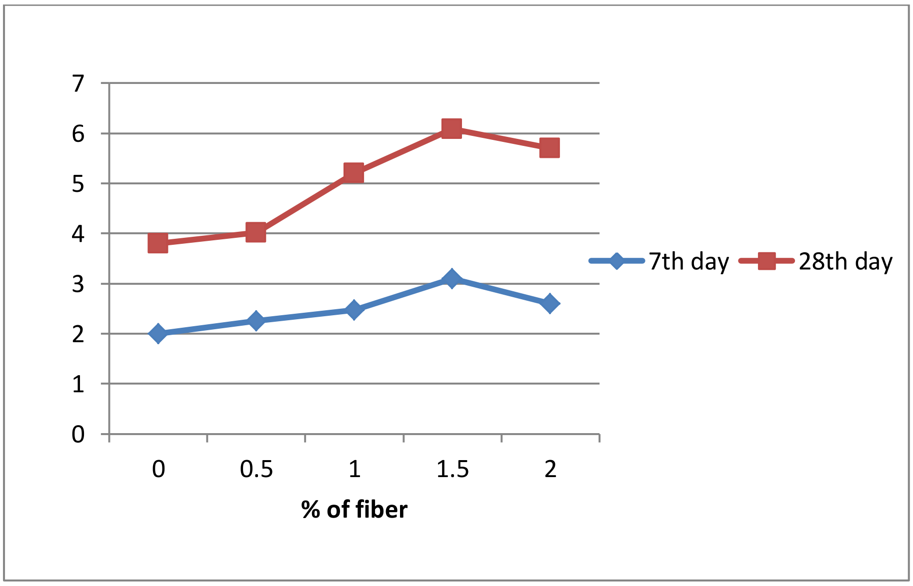

Fig 4.2 Graph showing split tensile strength results

Table 4.4 Flexural Strength

Flexural Strength (N/mm^2)		
% of fibers	**7th day**	**28th day**
0	2.1	3.53
0.5	2.2	3.56

1.0	2.7	4.44
1.5	3.4	4.87
2.0	3.0	4.80

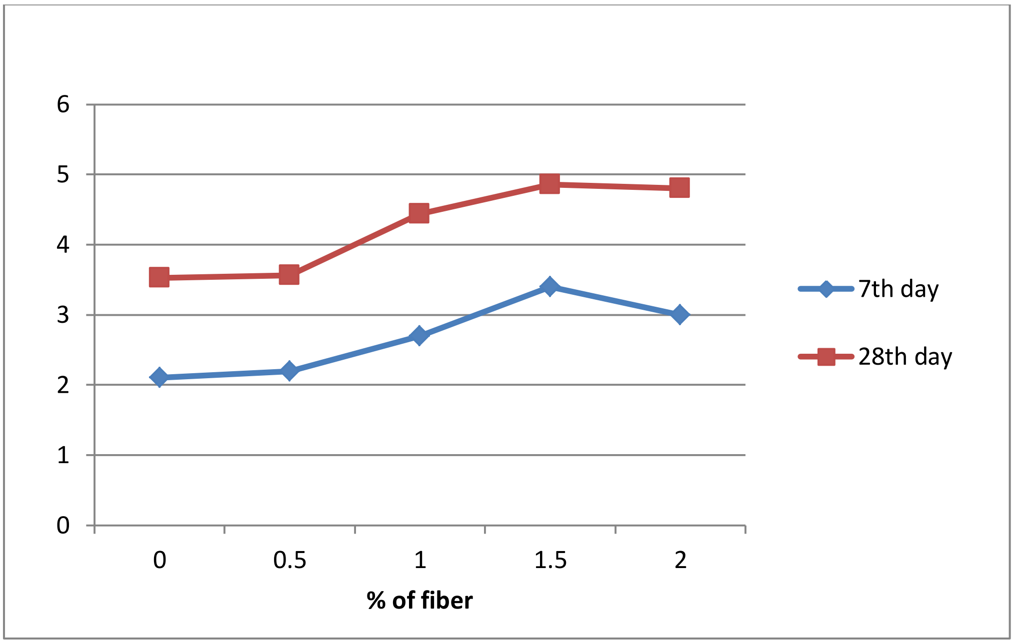

Fig 4.3 Graph showing flexural strength results

5 Conclusion

- In this study specimens were casted based on Nan-Su mix design method for M30 grade SCC and achieved maximum strength for 7-days & 28-days.
- In this SCC suggested mix design procedure gives higher fine aggregate content but smaller content of coarse aggregate, hence the passing capacity along the voids of reinforcing bars could have been increases.
- The addition of fibers into the concrete mixture marginally improves the strength properties at 28 days.
- In this experimental study with 0.15% of fiber the maximum strength of concrete is achieved. Polypropylene fibers reduce the water permeability, plastic shrinkage and settlement and carbonation depth.
- Polypropylene fibers enhance the strength of concrete, without causing the well known problems, normally associated with steel fibers. The compressive strength, split tensile strength and flexural strength increase with the addition of fiber.
- The polypropylene fiber dose not contributes on compressive strength much better but it reduce the cracks and crack propagation.

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