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EFFECT OF POLYPROPYLENE ON COMPRESSIVE STRENGTH PROPERTIES OF CONCRETE

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ABSTRACT

The present-day world is witnessing the construction of very challenging and difficult civil engineering structures. Concrete being the most important and widely used material is called upon to possess very high strength and sufficient workability properties. Efforts are being made in the field of concrete technology to develop such concretes with special characteristics. One such effort is the addition of different fibres to concrete for increasing the strength aspects of concrete. Some of the commonly known fibres are steel, glass, carbon and organic fibres. In the present study we are using Polypropylene fibre. Polypropylene fibre falls under the economical class i.e., without any extra expenditure (out of the total cost of concrete) it can be used. The effect of fibre on compressive strength was studied for different fibre content on M-40 grade concrete designed as per IS 10262-2019. The maximum size of aggregates used was 20mm. To study the effect on compressive strength of cubes were casted and tested. The size of short fibres used were 20mm. The effect of this short fibres on concrete workability, compressive strength was carried out.

Keywords: Polypropylene fibre, M40, compressive strength, workability.

1. INTRODUCTION

1.1 General

Concrete is the most widely used construction material which has several desirable properties like high compressive strength, stiffness and durability under normal usual environmental factors. While at the same time concrete found to be brittle and weak in tension. It is well known that concrete mixed with other material was applied for resistance purpose.

Fiber reinforces concrete is a family of composite materials that combine the high compressive strength properties of cement mortars with significantly increased impact, flexural and tensile strengths imparted by the fiber reinforcement.

Without any fiber in the concrete there was development of the cracks due to plastic shrinkage, drying shrinkage and other reasons of changes in volume of concrete. The development of these micro cracks causes elastic deformation of concrete. The presence of fibers provides crack arresters. When the first crack occurs in the matrix, the strong fibers pick up the load. That support is stronger than the matrix itself, so the next crack must occur elsewhere. More loading adds only new cracks, immediately arrested, rather than causing first cracks to propagate. Failure develops as a gradual, like - plastic yielding.

Concrete is most widely used man made construction material in the world and is second to water as the most utilized substance on the planet. Concrete has its mould ability in to any required structural form and shape due to its fluid behavior at early ages. Concrete essentially consist of a binder and mineral filler. This is the only construction material which is manufactured at site. The concrete industry uses 12.60 billion tons of raw materials each year and hence, is the largest user of natural resources in the world.

The global production of concrete has reached a value of more than one ton of concrete per capita of planet. Concrete made with Portland cement has certain characteristics; it is relatively strong in compression but weak in tension and tends to be brittle. This poor tensile strength of the concrete is overcome by adding steel reinforcement in the tension zone by providing long bars. The brittle nature of concrete can be overcome by the application of discrete fibers. Reinforcement with fibers has been proved an effective and economical way to convert cementitious material in to a tough and ductile product. The conventional concrete has limited ductility, low impact and abrasion resistance and little resistance to cracking.

To improve the ductility of concrete composite polypropylene fibers have been added in small proportion to improve its performance. The ductility of concrete composite depends on the ability of the fibers to bridge cracks at high level of strain. It is well demonstrative that the sudden failure of brittle concrete is eliminated with the addition of discrete fibers and gradual release of fracture energy. Fibers inhibit micro crack formation by strengthening the matrix and thereby control brittle failure. Extensive research on fiber reinforced concrete began in 1960. Fiber reinforcement is predominantly used for crack control and not for structural strengthening.

1.2 Polypropylene Fiber

Polypropylene is a versatile and widely used polymer, Polypropylene fiber resins are a general class of thermo plastics produced from polypropylene gas. It is petroleum by product. Polypropylene additions in cement concrete have shown significant improvement in the strength, durability of cement matrix and acts as fill materials for the pores in concrete.

Polypropylene fibers are new generation chemical fibers. They are manufactured on large scale and have fourth largest volume in production after polyesters, polyamides and acrylics. About 4 million tonnes of polypropylene fibers are produced in the world in a year. Polypropylene fibers were first suggested for use in 1965 as an admixture in concrete for construction of blast resistant buildings meant for the US Corps of Engineers. Polypropylene fiber is used in the construction industry as a secondary reinforcement which arrests cracks, increases resistance to impact/abrasion and greatly improves the quality of construction. These fibers are manufactured using conventional melt spinning. The commonly used fibers are steel, glass, polymeric, carbon, asbestos and natural fibers.

Fig. 1: Polypropylene fiber.

The polymeric fibers such as polypropylene, polyethylene, polyester and acrylic fibers are becoming popular these days. Polypropylene fibers were formerly known as Stealth. These are micro reinforcement fibers and are 100% virgin homopolymer polypropylene graded monofilament fibers.

2. REVIEW OF LITERATURE

M. Tamil Selvi et al (2013) is study the durability properties of M30 grade of concrete reinforced individually with 4% of steel and polypropylene fibers, respectively, as well as with hybrid fibers consisting of 2% steel and 2% polypropylene fibers respectively and to evaluate their strength at 7, 28, and 90 days. They conducted the rapid chloride permeability test, water absorption test, compressive strength and split tensile strength at 7, 28, 56 and 90 days and the test results show that the addition of steel and polypropylene fibers to concrete exhibit better performance.

Priti A. Patel et al (2012) done an experimental investigation explored properties such as compressive strength, flexural strength, split tensile strength and shear strength of polypropylene fiber reinforced concrete. Conventional concrete has two major drawbacks: low tensile strength and a destructive and brittle failure. In an attempt to increase concrete ductility and energy absorption, researcher introduced polypropylene fiber reinforced concrete (PFRC). Their study is part of a research program on evaluating the performance of polypropylene fiber reinforced concrete.

Roohollah Bagherzadeh et al (2012) has been studied the influence of polypropylene fibers in different proportioning and fiber length to improve the performance characteristics of the lightweight cement composites. In this study they used fibers in two different lengths (6mm and 12mm) and fiber proportions (0.15% and 0.35%) by cement weight in the mixture design. Hardened concrete properties such as compressive strength, splitting tensile strength, flexural strength, water absorption, and shrinkage were evaluated at 7- and 28-day.

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3. OBJECTIVE AND METHODOLOGY

3.1 Objective

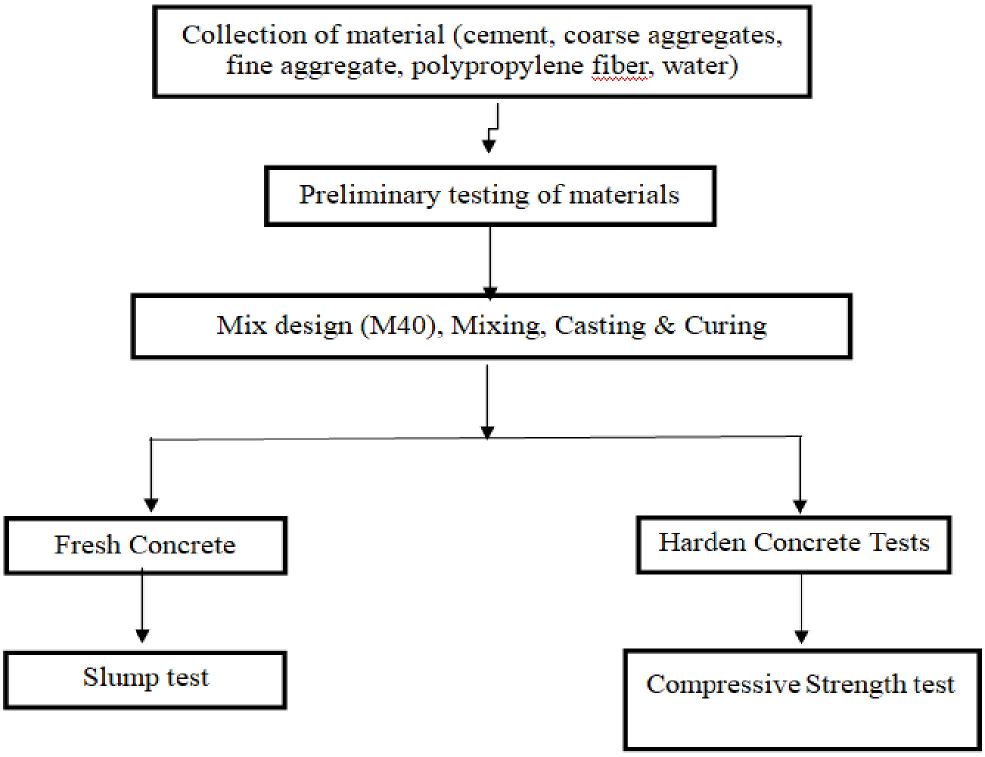
i) To develop mix design methodology for mix 40MPa

ii) To study the effect of adding different percentages (0% - 2.5%) of fiber by the whole the weight of concrete in the preparation of fibre reinforced concrete mix.

iii) To determine the workability of freshly prepared concrete by Slump test.

iv) To determine the compressive strength of cubes at 7, 14, 28 days.

3.2 Methodology Flow chart



3.3 Mix design

Table. 1: Quantities of materials for cement concrete.

Material	**Quantity** (kg/m^3)
Cement (grade 53)	450
Fly ash	19
Fine aggregates	635
Coarse aggregates	1109
Water	197.16
Water: cement	0.42

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The final mix proportions are:

Cement: fly ash : fine aggregate: coarse aggregate = **1: 0.042: 1.411: 2.46**

Table. 2: Quantities of materials for preparation 1 cube (without fiber).

Material	Quantity (kg/m^3)	Final volume	Weight (Kg)
Cement	450	Assme 10% wastage, V= (100%+10%) x $(0.15)^3$ = 0.00371 m^3	1.67
Fly ash	19		0.0705
Fine aggregates	635		2.35
Coarse aggregates	1109		4.11
Water	197.16		0.731 ml
Water: cement	0.42		-

Table. 3: Quantities of materials for preparation 1 cube (with fiber).

% Fiber	Cement (kg)	Fly ash (kg)	Fine aggregate (kg)	Fiber (kg)	Coarse aggregate (Kg)	Water (ml)
0	1.67	0.0705	2.35	0	4.11	705
0.5			2.115	0.0083		
1			1.88	0.0167		
1.5			1.645	0.0250		
2			1.41	0.0334		
2.5			1.175	0.0417		

4. EXPERIEMENTAL WORK

4.1 General

Initially the materials properties checked after those five different types of specimens (with varying fiber %) were developed in the in the laboratory and Cubes of 150mm size cast for testing compression. The properties by materials mentioned below tables.

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Table. 4: Physical properties of materials.

Material	Property	Referred code
Cement	Fineness: 4%	IS 1489 (Part 1)-1991
	Specific gravity: 3.15	IS 1489 (Part 1)-1991
	Normal consistency: 31%	IS 1489 (Part 1)- 1991/ IS 4031(Part 5)-1999
	Initial setting time: 45min	
	Final setting time: 325 min	
Fine aggregate	Specific gravity: 2.67	IS 2386 (Part 3)-1963
	Water absorption: 1.1%	
Coarse aggregate	Specific gravity: 2.74	
	Water absorption: 0.9 %	

4.2 Specimens Preparation

The above specified concrete grade was poured in moulds of cubes, Specimen were prepared with varying percentage of fiber. A total of 54 specimens are required for 7, 14 and 28 days testing after curing of cubes.

4.2.1 Mix Proportion

In this study, control mix of M40 grade of proportion was designated with a water cement ratio of 0.50 as per IS10262-2019 to achieve a target compressive strength of 26.6. In this study, have added (0.5%, 1%, 1.5%, 2% & 2.5%) of fibre by mass of cement.

Fig. 2: Mixing of concrete.

4.2.2 Casting

Standard cast iron cubes of dimension 150 mm X 150 mm X 150 mm were used to cast the specimen for compression test. The side plates of the mould were sufficiently stiff to eliminate spreading and warping. Before the concrete was placed in the mould, all the joints

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were checked thoroughly for any leakage. A thin film of grease was applied to cover the joints between the halves of the mould at the bottom surface of the mould and its base plate in order to ensure that no water escaped.

Fig. 3: Cube moulds.

Fig. 4: Casted cubes.

4.2.3 Curing

After casting the molded specimens are stored in the laboratory at room temperature for 24 hours. After these periods the specimens are remove from the moulds and immediately submerged in clean, fresh water of curing tank specimens are cured for 7, 14 and 28 days in the present investigation work.

Fig. 5: Curing of cubes.

4.2.4 Slump cone test

Slump test is the most commonly used method for measuring the consistency of concrete. It can be employed either in the laboratory or at the site. The test is popular owing to its simplicity. The apparatus for conducting slump test consists of a mould in the form of a frustum of a cone having internal dimensions as per IS 1199-1959. The slump cone is placed on a clean non-absorbent tray. The mix concrete is filled in the slump cone in four layers, compacting each layer by tamping 25 times using the standard tamping rod. Care is taken to distribute the strokes evenly over the cross section. After filling the fourth layer, the top surface is leveled off using a trowel. Immediately, the slump cone mould is removed from the concrete by raising it slowly in a vertical direction. This allows the concrete to subside. The subsidence is referred to as the slump of concrete. The difference in level between the height of the mould and the highest point of the subsided concrete is measured in millimetres. This difference in height in “mm” is referred to as the slump of concrete.

4.2.5 Harden properties of concrete

The strength related tests were carried out on hardened cement concrete to determine the strength related properties such as cube compressive strength.

For cube compression tests on concrete, cube of size 150mm were employed. All the cubes were tested in saturated condition after wiping out the surface moisture from the specimen. For each trial mix combination, three cubes were tested at the age of 7, 14 and 28 days of curing using 400 Ton capacity compression testing machine (CTM) as per BIS: 516-1959.The tests were carried out at a uniform stress after the specimen has been centred in the testing machine. Loading was continued until the dial gauge needle just reserves its direction of motion. The reversal in the directions of motion of the needle indicates that the specimen has failed. The dial reading at the instant was noted, which is the ultimate load. The ultimate load divided by the cross - section area of the specimen is equal to the ultimate cube compressive strength.

$$Compressive\ strength = Load\ /\ Area\ (N/mm^2)$$

Fig. 6: Compressive strength test.

5. RESULTS AND DISCUSSIONS

The Polypropylene fibre reinforced concrete; results obtained are shown below in tabular

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form:

5.1 Workability of concrete (Slump cone test)

Table. 5: Result of slump test.

S. No	% Of Fiber	Slump (mm)
1	0	90
2	0.5	94
3	1	97
4	1.5	100
5	2	102
6	2.5	105

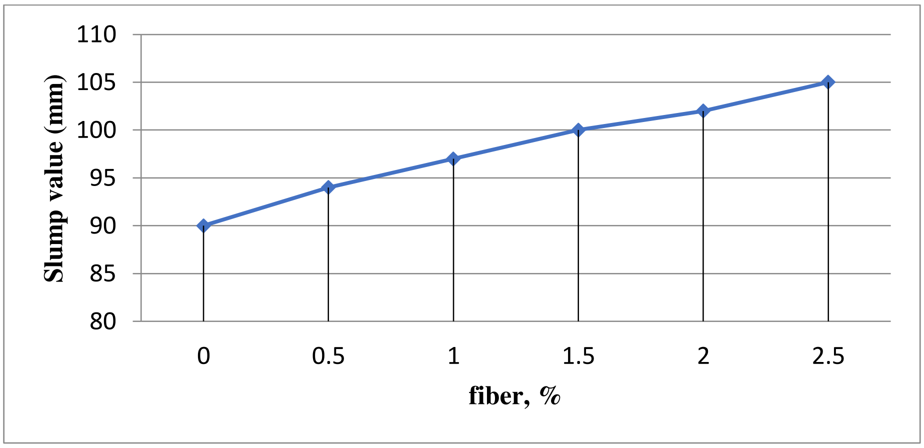

Fig. 7: Slump test results.

The above figure shows the slump results. It was observed that, the slumps increase as the fibre content was increased in the mix.

5.2 Compressive Strength of Concrete (in N/mm^2)

The 7, 14, 28 days compressive strength was studied and the values of 3 samples studied are shown in the tabular form. Table 5.2 shows the data of 7, 14, 28days compressive strength obtained. Below tables gives the 7, 14, 28 days compressive strength of concrete with maximum nominal size of aggregates 20mm. The 7, 14, 28 days compressive strength was also plotted Fig 5.2 by taking the average of these three values overall an increase in the compressive strength was observed with addition of fibres as compare to conventional concrete. The optimum compressive strength gains for 2% addition of fiber in the concrete mixes.

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Table. 6: Compressive strength of concrete

Fiber (%)	Avg Compressive strength (N/mm2)		
	7days	14days	28days
0	26	35.3	39.2
0.5	26.87	36.45	40.8
1	27.56	37.2	41.3
1.5	28.2	37.87	41.7
2	28.94	38.2	42
2.5	25.4	36.9	40.9

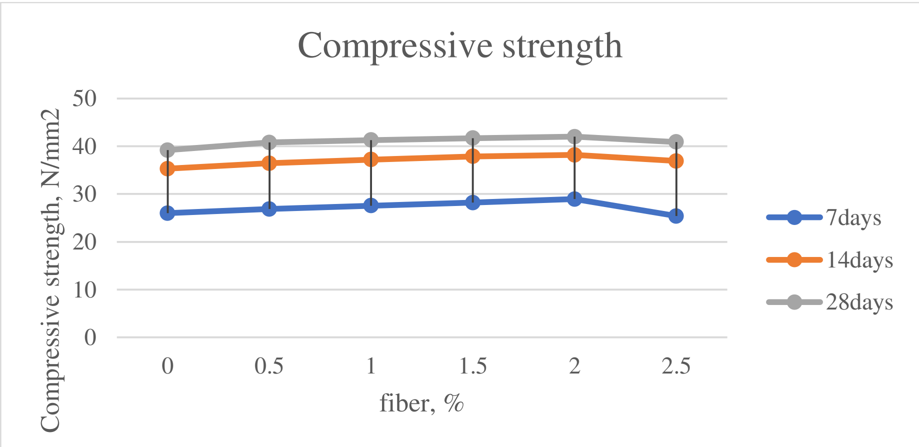

Fig. 8: Effect of fibres on 7-, 14- and 28-days compressive strength.

6. CONCLUSIONS

The main role that polypropylene fibers play in the structure of concrete is the reduction of plastic shrinkage cracks. In Table 5.2 the influence of the inclusion of the polypropylene fibers to the concrete on compressive strength properties is presented. Many features of polypropylene fiber reinforced concrete are enhanced as a result of mix modification. However, there are also properties whose effect is neutral or hard to clear evaluation. Additionally, special attention should be paid to the workability of fiber reinforced concrete, since it can undergo significant deterioration when an excessive amount of fibers is incorporated.

In this experimental program the effect of short discrete constructional scrap Polypropylene fibres with a size 20mm length on the compressive strength of concrete was studied.

The compressive strength of concrete is little affected by the presence of short discrete Polypropylene fibres with fibre content in the range 0.5 to 2.5 % of steel fibre content by load of concrete.

In compressive strength, the addition of steel fibre the strength is increasing up-to 1.5% after that strength is decreasing but it's better than conventional concrete mix. It is concluded that the strength is increasing while increasing the percentage of Polypropylene fibre. The optimum dosage of Polypropylene fibre used in concrete mix was 1.5% for the whole weight of concrete. The Workability of concrete increases with increasing fibre content.

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