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An Experimental Study on Mechanical Properties of Carbon Fiber Reinforced Concrete

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Abstract -*Fibers have the characteristics to enhance the endurance of concrete..One of them is carbon fiber. These carbon fibers have superb mechanical properties and may be utilized more effectively. This study is focused towards analyzing the variation in strength of carbon fiber concrete at variable fiber contents and to establish it with that of conventional concrete. The mechanical properties analyzed are compressive strength, tensile strength and flexural strength of carbon fiber concrete at (0.3%, 0.6%,0. 9%,1%, 1.2%) percentages by volume of concrete. Result data clearly shows percentage increase in compressive strength, split tensile strength and flexural strength for M25 grade of concrete in 7 days and 28 days with respect to the variation in % addition of carbon fibers. Maximum increase in strength was achieved at 1% addition of fiber content and it can be considered as optimum dosage.*

***Key Words*: Carbon fibers, Reinforced concrete, compressive strength, tensile strength, flexural strength.**

1. INTRODUCTION

Concrete is a composite material made from a filler which represented by the coarse granular material firmed in matrix which represented by the cementitious materials (the binder). The binder will fill the spaces between the filler particles and bond them together. However, it is a weak material having low rigidity and low strain ability that effect its tensile strength. For this purpose, fibre reinforced concrete(FRC)was created.

1.1 Carbon fiber

Carbon fiber is a carbon filament consists of carbon atoms, the filaments together bound with polymer resin with the means of heat under certain pressure. It is a highly spreadable light weight material.

Carbon fiber is manufactured by heating the filaments below 400 c. The filaments are placed in carbonize treatment, the fibers are heated to about 800c in an environment without oxygen to remove the impurities of carbon. Fibers are graphitized and it stretches the fibers between 50 to 100 percent elongation and heated under the temperature of 1100c to 3000c. It results in the desired tensile strength. The surface treatment and epoxy sizing are last steps for the Manufacture of the carbon fiber.

Carbon fibers have low density, high thermal conductivity, good chemical stability and excellent abrasion resistance, and it can be used to reduce cracking and shrinkage. These fibers increase structural properties such as tensile and flexural strengths, flexural toughness and impact resistance. Carbon fibers alsoincrease durability and dry shrinkage. However, the addition of carbon fibers decreases the electrical resistance.

The properties of carbon fibers, such as high stiffness, high tensile strength, low weight, high chemical resistance, high temperature tolerance and low thermal expansion, make them very popular in aerospace, civil engineering, military, and motorsports, along with other competition sports. However, they are relatively expensive when compared to similar fibers, such as glass fibers or plastic fibres.

1.2 Fiber reinforced concrete

Fibre Reinforced Concrete (FRC) is cement concrete Reinforced mixture with randomly distributed discrete Fibres. In the FRC, a numbers of small fibres are dispersed and distributed randomly in the concrete at the time of mixing, and thus improve concrete properties in all directions. Addition of loosely spaced and uniformly dispersed fibres to concrete acts as crack reducer and improves its properties. It has been used in construction with its higher flexural, tensile strength, resistance to splitting, impact resistance and excellent permeability and Frost resistance.

Fibres help with enhancing is better ductile strength, flexural strength, toughness furthermore effect the concrete quality positively. Moreover, carbon fibres have low density, particularly compared with steel fibre. Their strength-to density proportion is the highest amongst those most elevated fibres types. Carbon fibres have a higher quality compared to metallic fibres. This was the motive behind use of carbon fibers in concrete.

The main objective of this paper is to study the mechanical properties of Carbon Fiber Reinforced Concrete (CFRC) with a wide range of five fiber contents and up to 1.2%. An Experimental study is carried out to investigate concrete reinforced with carbon fiber under Several tests:

compressive strength, splitting tensile strength test, and flexural Strength test. Investigated fiber content dosage are: 0%, 0.3%, 0.6%, 0..9%, 1% and 1.2% by volume of concrete.

2. MATERIALS

Cement: Ordinary Portland cement of grade 53 is used for this work. The brand of cement used was Ultra Tech OPC with grade 53.The cement was gray and free from lumps.
Aggregates: In this research work fine aggregates used was river sand zone II and coarse aggregates used were crushed stones. These materials were easily available from local market.
Water: Clean tap water was used for mixing and curing of concrete.
Carbon Fibers: The Carbon fibers used for this work were black colour of 10mm length and 0.44mm thickness.

Fig 1: Sample: Carbon fiber

3. METHODOLOGY

1. Properties of various constituents of concrete viz, Cement, fine aggregates, coarse aggregates and Carbon Fibers were determined, by carrying out various tests.
2. Grade M25 concrete was designed as per IS: 10262 - 2009, which was used as reference mix.
3. Carbon Fibers were added in 0%, 0.3%, 0.6%, 0.9%, 1% and 1.2% by volume of Concrete.
4. Cube, cylinders and beams were casted and curing was done.
5. Compressive strength test, split tensile strength test and Flexural test was done.

Mix Proportions for M25 grade of Concrete

Cement = 354.16 kg/m3
Water Content = 170 kg/m3
Fine aggregate = 702.316 kg/m3
Coarse aggregate (20mm down) = 774 kg/m3
Coarse aggregate (10mm down) = 435 kg/m3
Fibers in (0.3%, 0.6%, 0.9%, 1%, 1.2%) Percentages.
Super Plasticizer = 9 litres.

The specimens of standard sizes and required shapes of different mix proportions were casted for 7, 28, days and curing process is carried out after 24hrs from casting time.

Fig 2: Casting of specimens

5. RESULTS AND DISCUSSIONS

All the tests have been performed in standard procedures and the results and load values obtained were tabulated and calculated in following sections.

5.1 Compressive Strength

Compressive strength tests were conducted on cured cube specimen at 7 days and 28 days age using a compression testing machine. The cubes were fitted at center in compression testing machine and fixed to keep the cube in position. The load was then slowly applied to the tested cube until failure.

Table: 5.1 Compressive Strength values

SI no.	Percentage of carbon content added	Compressive strength (N/mm^2)	
		7 days	28 days
1	0	15.25	28.37
2	0.3	15.72	35.42
3	0.6	16.22	40.42
4	0.9	19.15	43.44
5	1	20.65	45.44
6	1.2	14.03	36.08

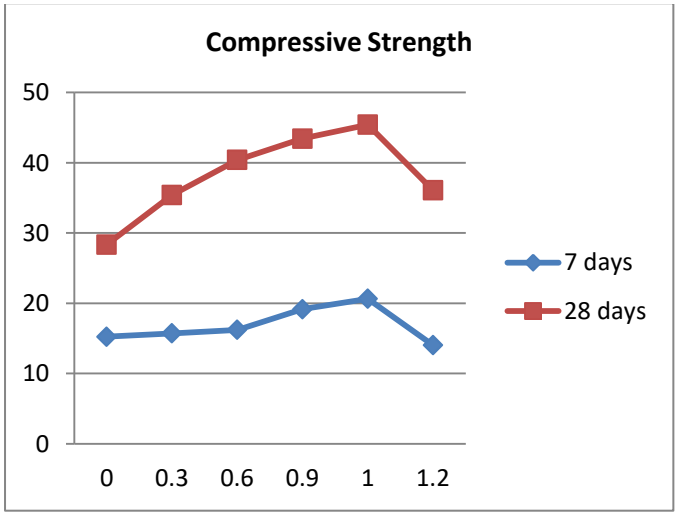

Chart -5.1: Compressive strength

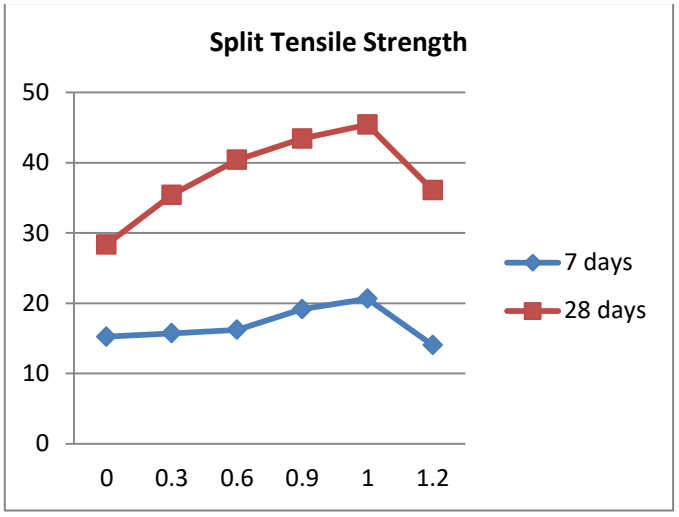

Chart-5.2: Split tensile strength

5.2 Split tensile strength

The split tensile test were conducted as per IS 5816:1999. The size of cylinder is 300mm length with 150mm diameter. The specimen were kept in water for curing for 7 days and 28 days and on removal were tested in wet condition by wiping water and grit present on the surface. The test is carried out by placing a cylindrical specimen horizontally between the loading surfaces of a compression testing machine and the load is applied until failure of the cylinder along the vertical diameter.

Table: 5.2 Split Tensile Strength values

SI no.	Percentage of carbon Content added	Split tensile strength (N/mm^2)	
		7 days	28 days
1	0	2.03	3.35
2	0.3	2.28	3.73
3	0.6	2.55	4.08
4	0.9	2.89	5.02
5	1	3.24	5.77
6	1.2	2.21	3.72

5.3 Flexural Strength

The Flexural test were conducted as per IS 516:1959. The size of beam is 150mm*150mm*700mm. The specimen were kept in water for curing for 7days and 28 days and on removal were tested in wet condition by wiping water and grit present on the surface. The test is carried out by placing a Beam specimen horizontally such that the load shall be divided equally between the two loading rollers, and all rollers shall be mounted in such a manner that the load is applied axially and without subjecting the specimen to any torsional stresses or restraints.

Table: 5.3 flexural strength values

SI no.	Percentage of carbon content added	strength (N/mm^2)	
		7 days	28 days
1	0	3.31	6.23
2	0.3	4.73	8.82
3	0.6	6.11	11.26
4	0.9	6.8	12.68
5	1	7.1	13.28
6	1.2	2.72	11.37

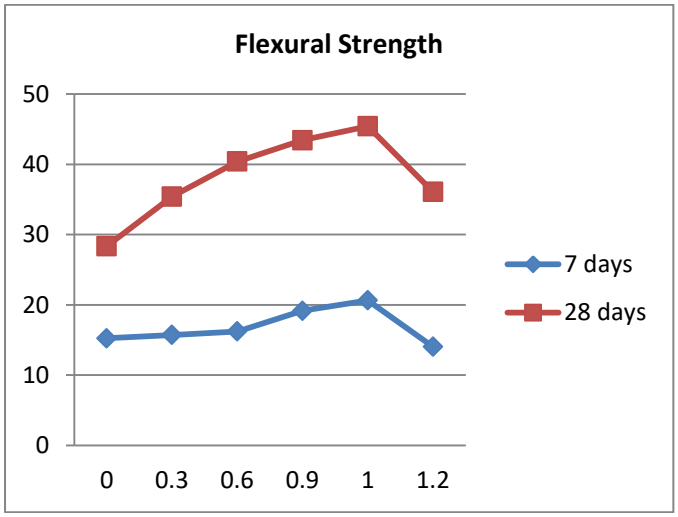

Chart-5.3: Flexural strength

6. CONCLUSIONS

The following important conclusions were drawn based on the results obtained from the experimental studies:

Compressive strength for M25 grade of concrete for different dosages of carbon fibers at 0.3%, 0.6%, 0.9%, 1% and 1.2% when compared with conventional concrete was found to increase by 24.8%, 42.36%, 53.11%, 60.11% and 25.41% respectively. The maximum percentage increase in compressive strength was achieved at 1.0% of fibre dosage and was found to reduce for 1.20% of fibre content.

When compared to conventional concrete, the tensile strengths for M25 grade CFRC For varying percentages of carbon fibers at 0.3%, 0.6%, 0.9%, 1% and 1.20%, increased by 11.34%, 21.79%, 49.85%, 73.13% and 11.44% respectively. The maximum percentage increase in Tensile strength was achieved at 1.0% of fibre dosage and was found to reduce beyond 1.2%.

Flexural strength for M25 grade of concrete for varying percentages of carbon fibers at 0.3%, 0.6%, 0.9%,
1% and 1.2% was increased by 41.59%, 80.73%, 103.53%, 113.16% and 82.80% respectively when compared to conventional concrete. The maximum strength was obtained at 1% and decreased beyond addition of 1.2% carbon fibers.

From the results it is observed that addition of 1% carbon fiber by volume of concrete increases Compressive strength tensile strength and flexural strength and decreases for 1.2% addition of carbonfibers.

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