EXPERIMENTAL INVESTIGATION ON INFLUENCE OF CARBON COMPOSITE FIBERS IN CONCRETE

Mr. A. Karthik[1], B. NIKHITHA[2], D. NIRANJAN[3], GOLLAPELY SAIKIRAN REDDY[4], RAVI KUMAR SINGH[5]

[1]*Asst. professor, Department of Civil Engineering, Aurora's Technological & Research Institute, Hyderabad, India.*

[2,3,4,5]*student, Department of Civil Engineering, Aurora's Technological & Research Institute, Hyderabad, India.*

***Abstract*—** The Carbon fiber is composed mostly of carbon atoms a widely solution for repairing and strengthening in the field of innovative construction world. They are thin, strong and flexible. It has high stiffness, high tensile strength, low weight, high chemical resistance, high temperature tolerance and low thermal expansion and Possessing strength up to five times that of steel and being one-third its weight. In this project the Compressive Strength and Split Tensile Strength of the concrete is find out by adding carbon fiber. The mix design was done for M30 grade concrete.

The strengthening of the concrete using CF in the strengthening system provides a versatile solution for extending the service life of concrete structures

***Keywords*— Carbon Fiber, Compressive strength and Tensile strength**

I. INTRODUCTION

Carbon fibers or carbon fibres are fibers about 5–10 micrometres in diameter and composed mostly of carbon atoms. Carbon fibers have several advantages including high stiffness, high tensile strength, low weight, high chemical resistance, high temperature tolerance and low thermal expansion. These properties have made carbon fiber very popular in aerospace, civil engineering, military, and motorsports, along with other competition sports. However, they are relatively expensive when compared with similar fibers, such as glass fibers or plastic fibers.

Classification and types

Based on modulus, strength, and final heat treatment temperature, carbon fibers can be classified into the following categories:

Based on carbon fiber properties, carbon fibers can be grouped into:

- Ultra-high-modulus, type UHM (modulus >450Gpa)
- High-modulus, type HM (modulus between 350-450Gpa)
- Intermediate-modulus, type IM (modulus between 200-350Gpa)
- Low modulus and high-tensile, type HT (modulus < 100Gpa, tensile strength > 3.0Gpa)
- Super high-tensile, type SHT (tensile strength > 4.5Gpa)

Based on precursor fiber materials, carbon fibers are classified into:

- PAN-based carbon fibers
- Pitch-based carbon fibers
- Mesophase pitch-based carbon fibers
- Isotropic pitch-based carbon fibers
- Rayon-based carbon fibers
- Gas-phase-grown carbon fibers

Based on final heat treatment temperature, carbon fibers are classified into:

- Type-I, high-heat-treatment carbon fibers (HTT), where final heat treatment temperature should be above 2000°C and can be associated with high-modulus type fiber.
- Type-II, intermediate-heat-treatment carbon fibers (IHT), where final heat treatment temperature should be around or above 1500°C and can be associated with high-strength type fiber.
- Type-III, low-heat-treatment carbon fibers, where final heat treatment temperatures not greater than 1000°C. These are low modulus and low strength materials.

Properties

- Carbon Fiber has High Strength to Weight Ratio (also known as specific strength)
- Carbon Fiber is very Rigid
- Carbon fiber is Corrosion Resistant and Chemically Stable
- Carbon fiber is Electrically Conductive
- Fatigue Resistance is good
- Carbon Fiber has good Tensile Strength
- Fire Resistance/Non-Flammable
- Thermal Conductivity of Carbon Fiber
- Low Coefficient of Thermal Expansion
- Non-Poisonous, Biologically Inert, X-Ray Permeable
- Carbon Fiber is Relatively Expensive
- Carbon Fibers are brittle

II. LITERATURE REVIEW

i. Pankaj Thakur, Khushpreet Singh

In this they mainly focus on strength properties of concrete by addition of carbon fiber with different percentages. The optimality and effect of fibers on concrete properties are studied and behaviour of concrete is experimentally verified by casting cubes, cylinders and beam specimen. They have observed that mechanical properties such as compressive strength, tensile strength, toughness, impact, flexural etc are greatly influenced by addition of carbon fibers, optimum properties of carbon fibers govern these properties and must carry out optimality study on carbon fibers. They have observed that the Addition of fibers with additional supplementary material such as fly ash, silica fumes, waste foundry sand etc should better performance by improving workability of concrete and inherent properties of concrete.

ii. Reshma sulthana, v sai manoj, a naveen, a vl kumar

The mix design is M25 and the mix design is designed from IS10262:2019 and various tests are conducted for fresh concrete such as slum cone test and compaction factor test for all types of mixes to find the workability of concrete. They have observed that by addition of cement with carbon fibers there is an increase of mechanical properties of up to 1% and there after decreasing pattern is observed. The workability property was not of much difference when compared to nominal concrete. The carbon fibers-based concrete has an increase of compressive strength of about 16.59 % when compared to nominal concrete. The carbon fibers concrete has an increase of split tensile strength of about 42.04 % when compared to nominal concrete. From this they have observed that the strength increases up to 1% and after that the strength of concrete starts decreasing.

iii. S. Muthukumaran, N. Murali Mohan and P. Sudha the mix design was done for M25 grade concrete

The mix design was done for M25 grade concrete It is observed that, Compressive strength, split tensile strength and flexural strength were increased with increasing amount of carbon fiber. Adding 1.5% of carbon fiber, the Compressive strength of concrete increases up to 26.23% for 28 days when compared with the conventional concrete. Adding 1.5% of carbon fiber, the split tensile strength of concrete increases up to 28.98% for 28 days when compared with the conventional concrete. Adding 1.5% of carbon fiber, the flexural strength of concrete increases up to 31.78 for 28 days when compared with the conventional concrete.

III. MATERIALS USED

i. CARBON FIBERS

Carbon fibers are fibers about 5 to 10 micrometres (0.00020–0.00039 in) in diameter and composed mostly of carbon atoms.[citation needed] Carbon fibers have several advantages including high stiffness, high tensile strength, low weight to strength ratio, high chemical resistance, high temperature tolerance and low thermal expansion. These properties have made carbon fiber very popular in aerospace, civil engineering, military, and motorsports, along with other competition sports. However, they are relatively expensive when compared with similar fibers, such as glass fiber, basalt fibers, or plastic fibers.

Fig. 1 Carbon fiber

ii. ORDINARY PORTLAND CEMENT

Ordinary Portland cement is the most common type of cement in general use around the world as a basic ingredient of concrete, mortar, stucco, and most non-specialty grout. It developed from other types of hydraulic lime in England in mid-19th century and usually originates from limestone. It is a fine powder produced by heating materials. to form clinker. After grinding the clinker, we will add small amounts of remaining ingredients. Many types of cements are available in market. When it comes to different grades of cement, the 53 Grade OPC Cement provides consistently higher strength compared to others .

Fig. 2 Cement

iii.Fine Aggregate

Sand is an industrial granular material which is mainly composed of finely divided rocky material and mineral particles. Hence, it is used as fine aggregate in concrete. The aggregate was tested for its physical requirements such as gradation, fineness modulus, specific gravity, moisture content, bulk density, bulking.

Fig 3. Fine Aggregate

COARSE AGGREGATE

Crushed aggregates of 20mm and downsize produced from local crushing plants were used. The aggregate exclusively passing through 20mm sieve size and retained on 6.3mm sieve is selected. The aggregates were tested for their physical requirements such as gradation, fineness modulus, specific gravity and bulk density, moisture content in accordance with IS: 2386-1963. The individual aggregates were mixed to induce the required combined grading.

Fig 4. Coarse Aggregate

IV. MIX PROPORTIONS

S.NO	MATERIALS	QUANTITY
1	CEMENT	177.854 kg
2	FINE AGGREGATE	191.57 kg
3	COARSE AGGREGATE	350.051 kg
4	WATER	62.307 kg
5	CARBON FIBER	1.275 kg

V. TESTS

1. COMPRESSIVE STRENGTH PROCEDURE:

Prepare the concrete in the required proportions and make the specimen by filling the concrete in the desired mould shape of 15cm x 15cmx 15cm cube with proper compaction, after 24 hrs place the specimen in water for curing. Take away the specimen from water when such as natural process time and wipe out excess water from the surface. Clean the bearing surface of the testing machine. Place the specimen within the machine in such a fashion that the load shall be applied to the other sides of the cube forged. Align the specimen centrally on the bottom plate of the machine. Rotate the movable portion gently by hand so it touches the highest surface of the specimen. Apply the load step by step at the speed of 140kg/cm³/minute until the specimen fails. Record the load at which the specimen failure takes place.

Fig 5. Curing of Cubes

Fig 6. Compressive Strength

2. SPLIT TENSILE STRENGTH

Grease the inside surface of the mould and pour the mix into the mould as layers. Compact each layer using a tamping rod. Tap each layer 30 times. Uniformly stroke the concrete mix and remove the excess concrete.

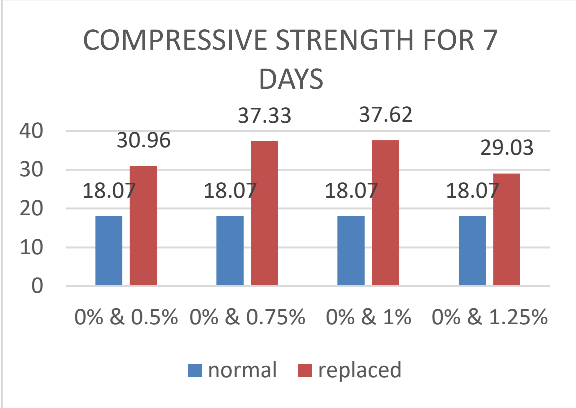
Then immerse the casted specimen in water for 24 hours at 27-degree Celsius. After that remove the specimen from the mould and immerse it in freshwater. The splitting tensile strength of concrete should be conducted at 7, 28 days of curing. Before starting the test, take the specimen from the immersed water and wipe the water. Then note the dimension and weight of the specimen. Place plywood strip above and below the specimen After that place the specimen on the testing machine. Then gradually apply load at a rate of 0.7 to 1.4 MPa/min. Record the load at which the specimen breaks.

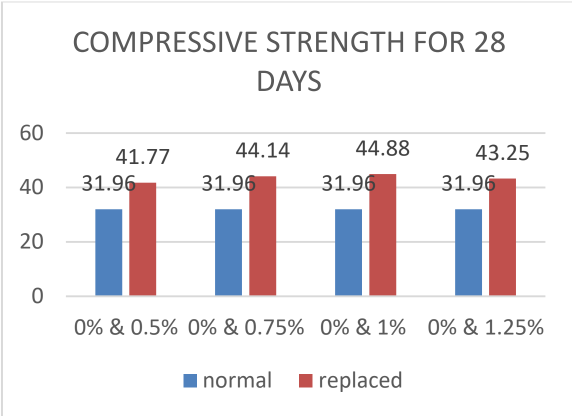
Fig 7. Split Tensile Strength

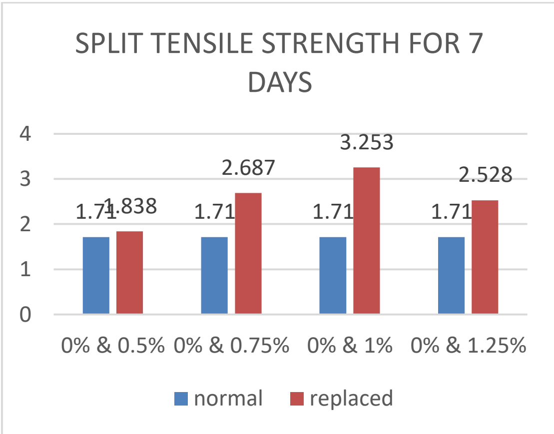
VI. RESULTS AND DISCUSSIONS

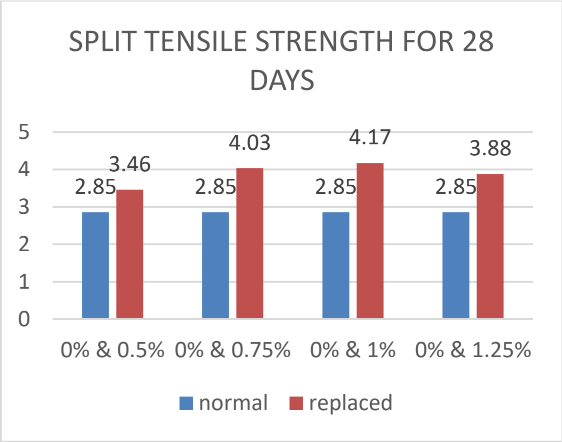
Table 2. Test Results

S.NO	% Of Carbon Fiber	Average Compressive Strength (N/mm^2)		Average Split Tensile Strength (N/mm^2)	
		7 DAYS	28 DAYS	7DAYS	28 DAYS
M1	0	18.77	31.96	1.71	32.98
M2	0.5	30.96	41.77	1.838	42.79
M3	0.75	37.33	44.14	2.687	45.15
M4	1	37.62	48.88	3.253	48.89
M5	1.25	29.03	43.25	2.528	44.26









VII. CONCLUSION

1) This report shows that the addition of carbon fibers in at concrete matrix in proves all the mechanical properties of concrete, especially compressive strength. The concrete at 28 days of curing will have higher compressive, tensile strength with carbon fibre.
2) Compressive strength for M30 grade of concrete for different dosages of carbon fibers at 0.5%, 0.75%, 1.00% and 1.25% when compared with conventional concrete was found to increase by 30.69%, 38.11%, 40.42% and 35.32% respectively. The maximum percentage increase in compressive strength was achieved at 1.0% of fibre dosage and was found to reduce for 1.25% of fibre content.
3) It was also observed that there was an increase in split-tensile strength of CFC for varying dosages of 0.5%, 0.75%, 1% & 1.25% and were found to be 21.4%,41.4%, 46.31% and 36.14% respectively more than that of conventional concrete. The maximum percentage increase in split-tensile strength was achieved at 1.0% of fibre dosage and was found to reduce beyond 1%.
4) From the results it is observed that there is an increase in strengths (Compressive and Split tensile) for CFC up to 1% of fibers by weight of concrete and decreases for 1.25% addition of carbon fibres
5) Finally it can be concluded that addition of 1% of carbon fibres increases strengths (Compressive and Split tensile) to the maximum extent when compared to 0.5%, 0.75% and 1.25% addition of carbon fibers. The durability of concrete can be enhanced by adding carbon fibres to concrete.

REFERENCES

1. D. Aditya Sai Ram, Ch. Surendra Reddy ISSN: 2349-084
2. Pankaj Thakur, Khushpreet SinghVolume: 05 Issue: 03 Mar-2018 p-ISSN: 2395-0072
3. International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056 Volume: 08 Issue: 07 July 2021 p-ISSN: 2395-0072
4. International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056 p-ISSN: 2395-0072 Volume: 08 Issue: 04 Apr 2021
5. Indian J. Sci. Res. 17 (1): 100-106, 2017
6. International Journal of Innovative Research in Science, Engineering and Technology, Volume 3, Issue 1, January 2014
7. International Journal of Civil Architectural Structural and Construction Engineering Volume: 8 No: 3, 2014
8. Sun Mingqing (1999) “Thermal self -monitoring of carbon fibre reinforced concrete”, Cement and Concrete Research vol.no. 29 (1999) PP. 769 – 771
9. Dragos-Marian Bontea (2000) “Damage in carbon fibre-reinforced concrete, monitored by electrical resistance measurement”, Cement and Concrete Research vol.no. 30 (2000), PP 651659
10. Mingqing Sun (2000) “Piezoelectric properties of carbon fibre reinforced concrete and plain cement paste during dynamic loading”, Cement and Concrete Research vol.no.30 (2000) PP.1593-1595
11. Zeng- Qiang Shi and D. D. L. Chung (1999) “Carbon fibre-reinforced concrete for traffic monitoring and weighing in motion”, Cement and Concrete Research Vol.no. 29 (1999) PP.435 – 439
12. Umit Serdar Camli and Baris Binici (2007) “Strength of carbon fibre reinforced polymers bonded to concrete and masonry”, Construction and Building Materials vol.no. 21 (2007) PP.1431 – 1446