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# Use of Carbon Fibre to Enhance Mechanical Properties of Concrete

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**ABSTRACT:** The use of fibres in concrete to improve pre- and post-cracking behaviour has gained popularity. Since 1967, several different fibre types and materials have been successfully used in concrete to improve its physical properties and durability. This is supported by an extensive number of independent research results showing the ability of fibres to improve durability and physical properties of concrete. Regardless of origin, cracking, when induced by chemical, mechanical, or environmental processes, results in deteriorated and less- durable concrete. In addition, the increased permeability caused by cracking can accelerate other deterioration processes such as freezing-and-thawing damage, again resulting in less- durable concrete. Fibre-reinforced concrete (FRC) is concrete with the addition of discrete reinforcing fibres made of steel, glass, synthetic (nylon, polyester, and polypropylene), and natural fibre materials. At appropriate dosages, the addition of fibres may provide increased resistance to plastic and drying shrinkage cracking, reduced crack widths, and enhanced energy absorption and impact resistance. The major benefit derived from the use of FRC is improved concrete durability.

**KEYWORDS:** Fibre-reinforced concrete(FRC) , Polypropylene, Deterioration

## I. INTRODUCTION

Carbon fibre is a long thin strand of carbon atoms that are bonded together in a honeycomb crystal lattice called Graphene. Some of the Graphene layers are folded around each other in random orientations but most are aligned parallel to the long axis of the strand. This makes the fibre incredibly strong along the axis of the strand.(highest APF) The strands are usually wound into a yarn then woven into a fabric (By altering the weave pattern the fabric can be stronger in one direction or be equally strong in all directions.) the fabric is then mixed with epoxy and moulded to form the desired shape.

### 1.1 Properties of Carbon Fibre

Carbon Fibre has High Strength to Weight Ratio (also known as specific strength) Strength of a material is the force per unit area at failure, divided by its density. Any material that is strong and light has a favourable Strength/weight ratio. Materials such as Aluminium, titanium, magnesium, Carbon and glass fibre, high strength steel alloys all have good strength to weight ratios. It is not surprising that Balsa wood comes in with a high strength to weight ratio.

#### 1) Carbon Fibre is Very Rigid

Rigidity or stiffness of a material is measured by its Young Modulus and measures how much a material deflects under stress. Carbon fibre reinforced plastic is over 4 times stiffer than Glass reinforced plastic, almost 20 times more than pine, 2.5 times greater than aluminium.

#### 2)Carbon Fibre is Corrosion Resistant and Chemically Stable

Although carbon fibre themselves do not deteriorate, Epoxy is sensitive to sunlight and needs to be protected. Other matrices (whatever the carbon fibre is imbedded in) might also be reactive.

#### 3)Carbon Fibre is Electrically Conductive

This feature can be useful and be a nuisance. In Boat building It has to be taken into account just as Aluminium conductivity comes into play. Carbon fibre conductivity can facilitate Galvanic Corrosion in fittings. Careful installation can reduce this problem.

#### 4) Fatigue Resistance is good

Resistance to Fatigue in Carbon Fibre Composites is good. However when carbon fibre fails it usually fails catastrophically without much to announce its imminent break. Damage in tensile fatigue is seen as reduction in stiffness with larger numbers of stress cycles, (unless the temperature is high). The orientation of the fibres and the different fibre layer orientation, have a great deal of influence on how a composite will resist fatigue (as it has on stiffness). The type of forces applied also result in different types of failures. Tension, Compression or Sheer forces all result in markedly different failure results.

#### 5) Carbon Fibre has good Tensile Strength

Tensile strength or ultimate strength is the maximum stress that a material can withstand while being stretched or pulled before necking, or failing. Necking is when the sample cross-section starts to significantly contract. If you take a strip of plastic bag, it will stretch and at one point will start getting narrow. This is necking. It is measured in Force per Unit area. A brittle material such as carbon fibre does not always fail at the same stress level because of internal flaws. They fail at small strains.

#### □ OBJECTIVES

□ Objectives for the project work are as follows:

1. Investigation on the concrete mixes containing 1%, 2% of carbon fibre in concrete to enhance its mechanical properties and increase compressive strength of concrete.
2. Evaluating and studying the effect of varying percentages of carbon fibre and comparing the results with normal concrete without any replacements.
3. To develop a possible use of carbon fibre suitable for sustainable construction materials.
4. To conduct compressive strength test.

## II. LITERATURE REVIEW

### Dr. Deborah & D.L Chung<sup>1</sup>

In this paper author has developed a formulation for carbon fibre reinforced concrete has been developed. This formulation uses short pitch-based carbon fibres in the amount of 0.5% of the weight of the cement. Compared to plain concrete, this formulation cost 39% more in materials and yields a flexural strength increase of 85% and a flexural toughness increase of 205% at 28 days of curing. When an air entrainer is used, this formulation, compared to plain air-entrained concrete, yields a flexural strength increase of 79% and a flexural toughness increase of 53% at 28 days of curing. Hence, the formulation works well for increasing the flexural strength, whether or not an air entrainer is used, but it is much more effective for increasing the flexural toughness when an air entrainer is not used. The increase in flexural toughness is due to the increase in both the flexural strength and the ductility. The aggregate size has little effect on the effectiveness of the above mentioned formulation.

The minimum carbon fibre volume fraction for the fibres to be effective for increasing the flexural strength is 0.1%. The optimum fibre length is such that the mean fibre length decreases from 12 mm before mixing to 7 mm after mixing. The fibre length decrease occurs in the Hobart mixer stage of the mixing procedure.

### Zeng-Qiang Shi, D.D.L. Chung<sup>2</sup>

This paper deals with Self-Monitoring Concrete for Traffic monitoring. Concrete is made Self-Monitoring by addition of Carbon Fibres. Traffic monitoring is an essential part of traffic control and management, involves real-time monitoring and requires strain sensors, which may be optical, electrical, magnetic, or acoustic. The sensors are conventionally attached to or embedded in the highway for which traffic monitoring is desired. The sensors suffer from (1) their sensing ability being limited to their immediate vicinities, (2) they are not sufficiently tensile and flexural properties, low drying shrinkage, high specific heat, low thermal conductivity durable, and (3) they are too expensive for wide-spread use. A relatively new technology involves the use of concrete itself as the sensor, so that no embedded or attached sensor is needed. Because the structural material is also a sensor, the whole structure is sensed and the sensor (just concrete) is durable and inexpensive. Hence, all three problems for conventional sensors are removed by the use of this self-monitoring concrete.

Self-monitoring concrete containing short carbon fibres (0.5% or 1.0% by weight of cement) is effective for traffic monitoring and weighing in motion. The resistance decreases reversibly with increasing stress up to 1 MPa and is independent of speed up to 55 mph.

### D.D.L. Chung<sup>3</sup>

This is a review of cement-matrix composites containing short carbon fibres. These composites exhibit attractive tensile and flexural properties, low drying shrinkage, high specific heat, low thermal conductivity, high electrical

conductivity, high corrosion resistance and weak thermoelectric behaviour. Moreover, they facilitate the cathodic protection of steel reinforcement in concrete, and have the ability to sense their own strain, damage and temperature. Fibre surface treatment can improve numerous properties of the composites. Conventional carbon fibres of diameter 15mm are more effective than 0.1mm diameter carbon filaments as reinforcement, but are much less effective for radio wave reflection (EMI shielding). Carbon fibre composites are superior to steel fibre composites for strain sensing, but are inferior to steel fibre composites in the thermoelectric behaviour. Short carbon fibre cement-matrix composites exhibit attractive, high electrical conductivity, high corrosion resistance and weak thermoelectric behaviour. Moreover, they facilitate the cathodic protection of steel reinforcement in concrete, and have the ability to sense their own strain, damage.

#### ACI Committee E-701<sup>4</sup>

This document is an introductory document on the topic of commonly used materials for reinforcement of concrete. This primer describes the basic properties and uses of these materials. It is targeted at those in the concrete industry not involved in designing with or specifying these materials. This bulletin provides some of the information important to understanding why reinforcement is placed in concrete. Most concrete used for construction is a combination of concrete and reinforcement that is called reinforced concrete. Steel is the most common material used as reinforcement, but other materials such as fibre-reinforced polymer (FRP) are also used. The reinforcement must be of the right kind, of the right amount, and in the right place in order for the concrete structure to meet its requirements for strength and serviceability.

From the above Literature, It is observe that researchers did the research on the parameters affecting the mechanical properties of Carbon Fibre Reinforced Concrete. In this work the effect of various volume fraction of the Carbon Fibre on the Carbon Fibre Reinforced Concrete.

#### ACI Committee 544 (Chairman- Nemkumar Banthia)<sup>5</sup>

This document addresses the physical properties and durability of fibre-reinforced concrete (FRC). The effects of fibre reinforcement are evaluated for various physical, short-term, and long-term benefits they impart to the concrete mixture. A variety of test methods, conditions, and properties are reported. The various properties listed, in addition to the wide variety of the choices available in formulating matrix systems, allow performance-based specification of concrete materials using fibres to become a viable option. This document provides a historical basis and an overview of the current knowledge of FRC materials for tailoring new, sustainable, and durable concrete mixtures This Report is divided into three sections. The first section discusses the physical properties of FRC in terms of electrical, magnetic, and thermal properties. Rheological properties, which affect fibre dispersion and distribution, are discussed using both empirical and quantitative rheology. Mechanisms of creep and shrinkage and the role of various fibre types in affecting both plastic shrinkage cracking and restrained shrinkage cracking are also addressed. Second section deals with areas where concrete durability is affected by the addition of fibres.

### III. METHODOLOGY

- **Properties of Concrete**

Testing of hardened concrete plays an important role in the controlling and confirming quality of raw material, which help to achieve higher efficiency of material used and greater assurance of performance of concrete.

Cube (150 x 150x 150 mm)

- **Curing:**

After moulding the test specimens are stored on the site at a place free from vibration under damp matting, sacks or other similar materials for  $24 \pm 0.5$  hours from the time of addition of water to the other ingredients.

The temperature of the place of storage should be within the range of 22°C to 32°C. After a period of 24 hours, they should be marked for later identification and removed from the moulds, stored in clean potable water at a temperature of 24°C to 30°C until they are transported to the testing laboratory.

- **Testing:**

After the required curing (i.e.3, 7 & 28 days etc), the specimens are tested under the compression testing machine.

The load should be applied gradually at the rate of 14 MPa per minute till the specimen fails. The testing shall be done on at least three specimens at each selected age. If the strength of any specimen varies by 15 % of the average strength, the results should be rejected.



**3.1 Casting Schedule :**

Cubes - (150×150×150) mm

Carbon Fibre (%)	3 Days	7 Days	28 Days	Total
Conv.conc. 0%	3	3	3	9
1.0%	3	3	3	9
2.0%	3	3	3	9
3.0%	3	3	3	9
			Total	36

Table No-3.1.1

**IV. RESULTS**

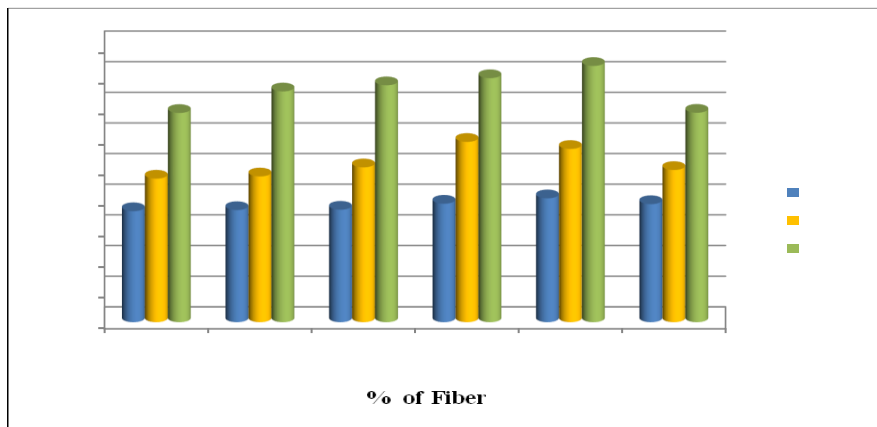
**4.1 Compressive Strength Result:**

Testing of hardened concrete plays an important role in controlling and confirming the quality of cement concrete work. Tests are made by casting cubes and cylinder from the actual concrete.

**4.2 For M25 grade of CFR Concrete**

- Size of cube = 150 mm x 150 mm x 150mm
- Mix Proportion = 1: 1.013 : 2.469
- W/C ratio = 0.37
- Type of Cement = PPC
- Manufacturer of Cement = Ultratech Cement
- Type of fibre = Carbon Fibre

In present study, compression test on cube for 3days, 7days & 28days, flexural test on beams for 28days and split tensile test on cylinder for 7days & 28days plain and varying percentage of carbon fibre reinforced concrete are carried out. The experimental results and discussion for various tests are described below.



4.2.1 Comparison of 3 days, 7 days & 28 days Comp. Strength

## V. CONCLUSION

1. The replacement of carbon fibre in concrete found to be increase in strength with 1.5% and 1% replacement than conventional concrete.
2. The 2 % replacement of carbon fibre not increase the strength much more
3. It is observed that the strength of concrete with 2.5% replacement is starting to reduce after 28 days.

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