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# EXPERIMENTAL INVESTIGATION ONPROPERTIES OF CONCRETE BY THE ADDITION OF CARBON FIBER

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## 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 carbon fiber is used to strengthen the concrete. The mix design was done for M25 grade concrete. The strengthening of the concrete using CF in the strengthening system provides an economical and versatile solution for extending the service life of concrete structures.**

**KEYWORDS:** Carbon Fiber, Metallic Fiber, Boron Fiber, Glass Fiber, Steel Fiber

Concrete is a admixtures of water, aggregate, and cement. Often, additives and reinforcements are included in the mixture to occur the desired physical properties of the material. When these ingredients are mixed together, they form a fluid mass that is easily molded into shape. Over time, the cement forms a hard matrix which binds the rest of the admixtures together into a durable stone-like material with many uses. Concrete has high compressive strength, but much lower tensile strength. For this reason, it is generally reinforced with materials for high tensile strength. The elasticity of concrete is relatively constant at low stress levels but a start decreasing at higher stress levels as matrix cracking develops. Concrete has a very low coefficient of thermal expansion and shrinks as it matures. All concrete structures crack to some extent, due to shrinkage and tension. Concrete that is subjected to long-duration forces is prone to creep. Concrete is a composite material composed mainly of water, aggregate, and cement.

Often, additives and reinforcements are included in the mixture to achieve the desired physical properties of the finished material. When these ingredients are mixed together, they form a fluid mass that is easily molded into shape. Over time, the cement forms a hard matrix which binds the rest of the ingredients together into a durable stone-like material with many uses. Concrete has relatively high compressive strength, but much lower tensile strength. For this reason it is usually reinforced with materials that are strong in tension (often steel). The elasticity of concrete is relatively constant at low stress levels but a start decreasing at higher stress levels as matrix cracking develops. Concrete has a very low coefficient of thermal expansion and shrinks as it matures. All concrete structures crack to some extent, due to shrinkage and tension. Concrete that is subjected to long-duration forces is prone to creep. Carbon fibers are a type of high-performance fiber available for civil engineering application. It is also called graphite fiber or carbon graphite, carbon fiber consists of very thin strands of the element carbon. Carbon fibers have high tensile strength and are very strong for their size. In fact, carbon fiber might be the strongest material. Carbon fibers have high elastic modulus and fatigue strength than those of glass fibers. carbon fiber reinforced polymers have more potential than aramid and glass fibers. They also are highly chemically resistant and have high temperature tolerance with low thermal expansion and corrosion resistance.

Carbon fiber-reinforced composite materials are used to make aircraft and spacecraft parts, racing car bodies, golf club shafts, bicycle frames, fishing rods, automobile springs, sailboat masts, and many other components where light weight and high strength are needed. Carbon fiber's high strength, light weight and resistance to corrosion make it an ideal reinforcing material.

**Figure 1: Carbon Fiber**

Several structural engineering applications utilize carbon fiber reinforced polymer because of its potential construction benefits and cost effectiveness.

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The usual applications include strengthening structures made with concrete, steel, timber, masonry, and cast iron. Retrofitting to increasing the load capacity of old structures like bridges to enhance shear strength and for flexure in reinforced concrete structures. Other applications include replacement for steel, prestressing materials and strengthening cast-iron beams.

## STUDY ABOUT FIBER

The addition of small closely spaced and uniformly dispersed fibers to concrete would act as crack arrester and would substantially improve its static and dynamic properties. This type of concrete is known as fiber reinforced concrete.

Fiber reinforced concrete can be defined as a composite material consisting of mixtures of cement, mortar or concrete and discontinuous, discrete, uniformly dispersed suitable fibers. Continuous meshes, woven fabric and long wires or rods are not considered to be discrete fibers. and its types

### Carbon Fiber

Carbon fibers are a type of high-performance fiber. It is also called graphite fiber or carbon graphite, carbon fiber consists of very thin strands of the element carbon. Carbon fibers have high tensile strength and are very strong for their size. In fact, carbon fiber might be the strongest material. Carbon fibers have high elastic modulus and fatigue strength than those of glass fibers. Considering service life, studies suggests that carbon fiber reinforced polymers have more potential than agamid and glass fibers. They also are highly chemically resistant and have high temperature tolerance with low thermal expansion and corrosion resistance.

**Figure 2: Carbon Fiber**

Carbon fiber-reinforced composite materials are used to make aircraft and spacecraft parts, racing car bodies, golf club shafts, bicycle frames, fishing rods, automobile springs, sailboat masts, and many other components where light weight and high strength are needed. Carbon fiber’s high strength, light weight and resistance to corrosion make it an ideal reinforcing material.

### Glass Fiber

Glass fiber-reinforced concrete uses fiber glass, much like you would find in fiberglass insulation, to reinforce the concrete. The glass fiber helps insulate the concrete in addition to making it stronger. Glass fiber also helps prevent the concrete from cracking over time due to mechanical or thermal stress. In addition, the glass fiber does not interfere with radio signals like the steel fiber reinforcement does.

**Figure 3: Glass Fiber**

### Steel Fiber

Steel fiber-reinforced concrete is basically a cheaper and easier to use form of rebar reinforced concrete. Rebar reinforced concrete uses steel bars that are laid within the liquid cement, which requires a great deal of preparation work but make for a much stronger concrete. Steel fiber reinforced concrete uses thin steel wires mixed in with the cement. This imparts the concrete with greater structural strength, reduces cracking and helps protect against extreme cold. Steel fiber is often used in conjunction with rebar or one of the other fiber types.

**Figure 4: Steel Fiber**

### Boron Fiber

Boron fiber (also commonly called "boron filament") is an amorphous elemental boron product which represents the major industrial use of elemental (free) boron. Boron fiber manifests a combination of high strength and high modulus. A common use of boron fibers is in the construction of high tensile strength tapes. Boron fiber use results in high-strength, lightweight materials that are used chiefly for advanced aerospace structures as a component of composite materials, as well as limited production consumer and sporting goods such as golf clubs and fishing rods.

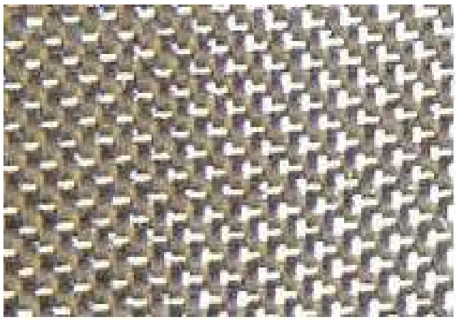


**Figure 5: Boron fiber**

**Metallic Fibers**

Metallic fibers are manufactured fibers composed of metal, plastic-coated metal, metal-coated plastic, or a core completely covered by metal. Gold and silver have been used since ancient times as yarns for fabric decoration. More recently, aluminium yarns, aluminized plastic yarns, and aluminized nylon yarns have replaced gold and silver. Metallicfilaments can be coated with transparent films to minimize tarnishing.

**Figure 6: Metallic fiber**

**Aramid Fibers**

Aramid fibers are a class of heat-resistant and strong synthetic fibers. They are used in aerospace and military applications, for ballistic rated body armor fabric and ballistic composites, in bicycle tires, and as anasbestos substitute. The name is a portmanteau of "aromatic polyamide". They are fibers in which the chain molecules are highly oriented along the fiber axis, so the strength of the chemical bond can be exploited.

## METHODOLOGY

Infrastructure development is raising its pace. Many reinforced concrete and masonry buildings are constructed annually around the globe. With this, there are large numbers of them which deteriorate or become unsafe to use because of changes in use, changes in loading, change in design configuration, inferior building material used or natural calamities. Thus repairing and retrofitting these structures for safe usage of these structures has a great market. There are several situations in which a civil structure would require strengthening or rehabilitation due to lack of strength, stiffness, ductility and durability.

Beams, columns, plates may be strengthened in flexure through the use of CFRP bonded to their tension zone using epoxy as a common adhesive. Due to several advantages of carbon fiber wrapping over conventional techniques used for structural repair and strengthening, the use of CFRP has becoming popular. The paper makes a comparative study between the load carrying capacity and ductility of an RCC beam and other beams with CFRP bonded. An experiment study is carried out to study the change in the structural behavior of R.C.C. beams wrapped with carbon fiber of different thickness, orientation and length to enhance the flexural and shear capacity of the beams along with the existing practice of doing the repair work.

**Table 1: Properties of Carbon Fiber**

| Materials | Property | Values |
|---|---|---|
| Carbon fiber | Yield strength (MPa) | 1315 |
| | Modulus of Elasticity (GPa) | 165 |
| | Length (mm) | 25 |
| | Diameter (micrometer) | 10 |
| | Tensile strength (MPa) | 1685 |
| | Density (g/cm$^3$) | 1600 |

## PROPOSED WORK

**Evaluation**

The compressive strength of cube specimen are shown in the below table 2.

**Table 2: Compressive strength at 7 days**

| % of Carbon Fiber | COMPRESSIVE STRENGTH(N/mm²) 7 DAYS | | | |
|---|---|---|---|---|
| | Sample 1 (N/mm²) | Sample 2 (N/mm²) | Sample 3 (N/mm²) | Average (N/mm²) |
| 0% | 15.56 | 15.11 | 15.33 | 15.33 |
| 0.5% | 21.33 | 22.00 | 22.67 | 22.00 |
| 1% | 25.11 | 26.22 | 25.56 | 25.63 |
| 1.5% | 25.78 | 26.67 | 26.44 | 26.29 |
| 2% | 23.11 | 21.78 | 22.44 | 22.44 |

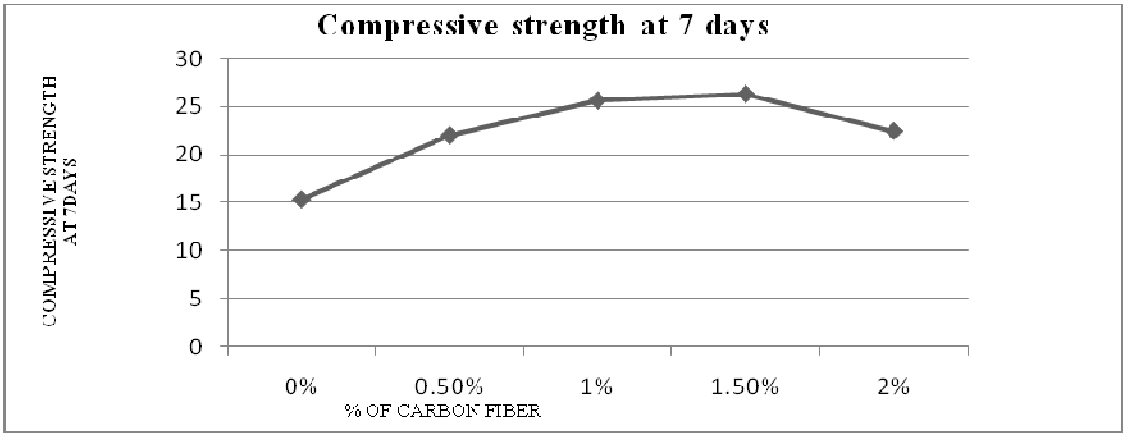
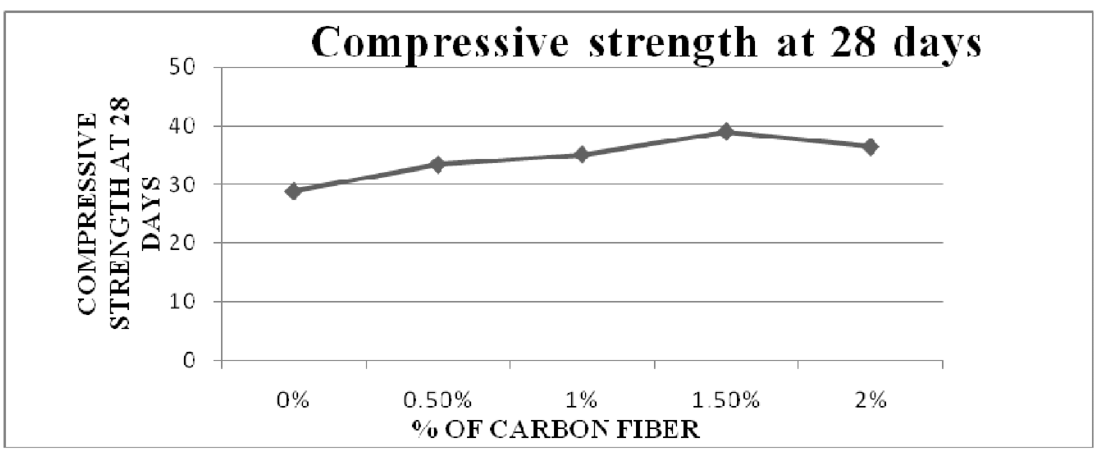



**Table 3: Compressive strength at 28 days**

| % of Carbon Fiber | COMPRESSIVE STRENGTH(N/mm²) 28 DAYS | | | |
|---|---|---|---|---|
| | Sample 1 (N/mm²) | Sample 2 (N/mm²) | Sample 3 (N/mm²) | Average (N/mm²) |
| 0% | 28.89 | 28.44 | 29.11 | 28.8 |
| 0.5% | 33.56 | 34.67 | 32.00 | 33.41 |
| 1% | 33.78 | 35.11 | 36.44 | 35.11 |
| 1.5% | 38.22 | 40.00 | 38.89 | 39.04 |
| 2% | 35.78 | 36.44 | 37.11 | 36.44 |




**SPLIT TENSILE STRENGTH AT 7 DAYS**

The split tensile strength of cylinder specimen are shown in the below table 3.

**Table 4: Split tensile strength at 7 days**

| % of Carbon Fiber | TENSILE STRENGTH(N/mm²) | | | |
|---|---|---|---|---|
| | Sample 1 (N/mm²) | Sample 2 (N/mm²) | Sample 3 (N/mm²) | Average (N/mm²) |
| 0% | 1.69 | 1.83 | 1.62 | 1.71 |
| 0.5% | 1.69 | 1.77 | 1.84 | 1.77 |
| 1% | 2.12 | 2.05 | 2.12 | 2.09 |
| 1.5% | 2.82 | 2.68 | 2.97 | 2.82 |
| 2% | 2.55 | 2.76 | 2.68 | 2.67 |

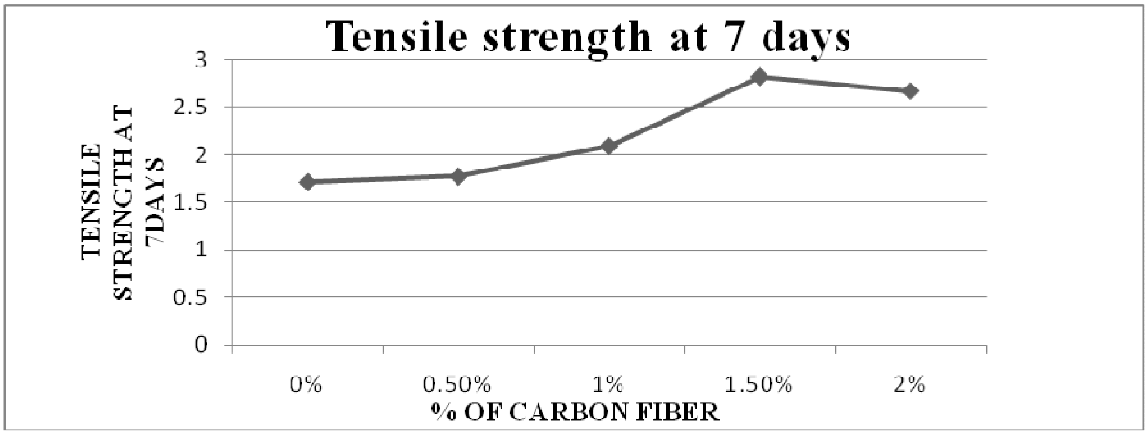
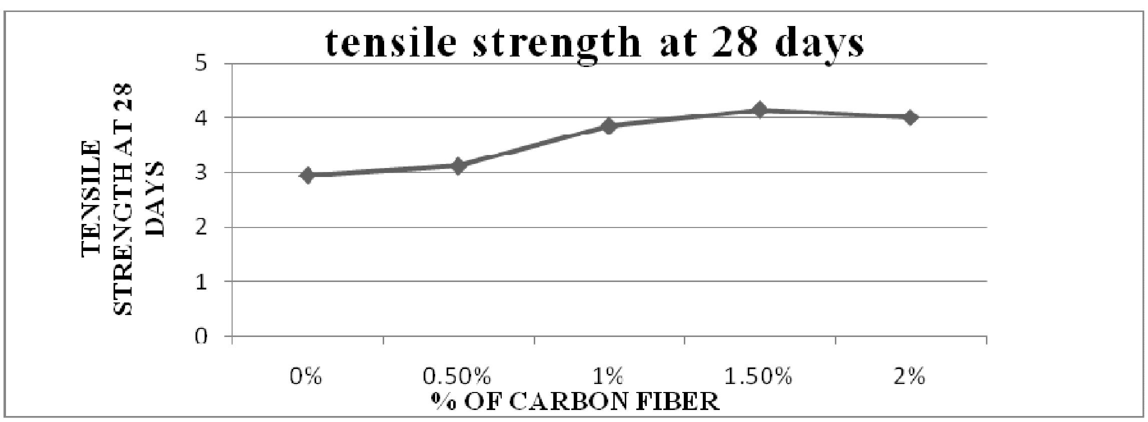



**Table 5: Split tensile strength at 28 days**

| % of Carbon Fiber | TENSILE STRENGTH(N/mm²) | | | |
|---|---|---|---|---|
| | Sample 1 (N/mm²) | Sample 2 (N/mm²) | Sample 3 (N/mm²) | Average (N/mm²) |
| 0% | 2.82 | 2.97 | 3.04 | 2.94 |
| 0.5% | 3.04 | 3.11 | 3.18 | 3.11 |
| 1% | 3.96 | 3.89 | 3.68 | 3.84 |
| 1.5% | 3.96 | 4.38 | 4.10 | 4.14 |
| 2% | 4.03 | 3.82 | 4.17 | 4.00 |




**Flexural Strength At 7 Days**

The flexural strength of beam specimen are shown in the below table 5.

**Table 6: Flexural strength at 7 days**

| % of Carbon Fiber | FLEXURAL STRENGTH(N/mm²) | | | |
|---|---|---|---|---|
| | Sample 1 (N/mm²) | Sample 2 (N/mm²) | Sample 3 (N/mm²) | Average (N/mm²) |
| 0% | 3.5 | 3.00 | 3.75 | 3.42 |
| 0.5% | 4.25 | 4.00 | 4.50 | 4.25 |
| 1% | 4.25 | 5.00 | 4.75 | 4.67 |
| 1.5% | 6.00 | 5.75 | 6.75 | 6.16 |
| 2% | 5.25 | 5.75 | 5.00 | 4.16 |

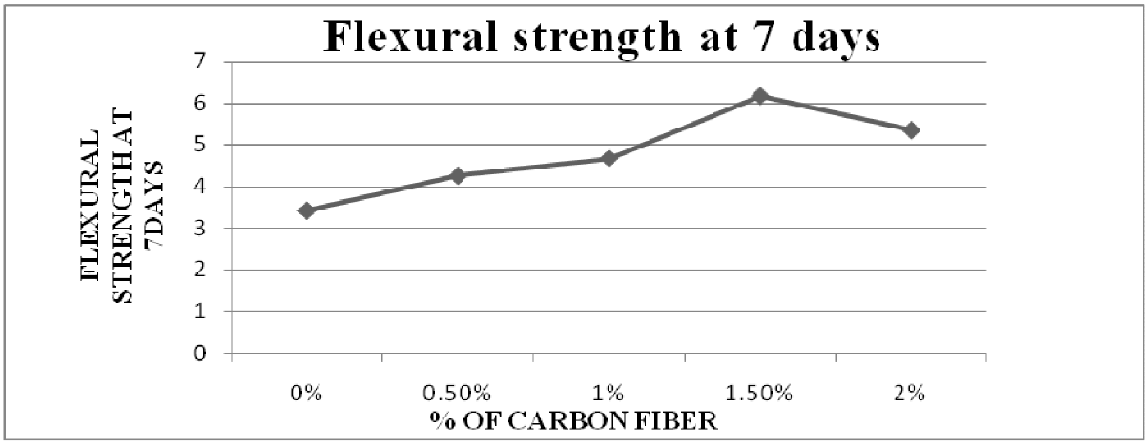
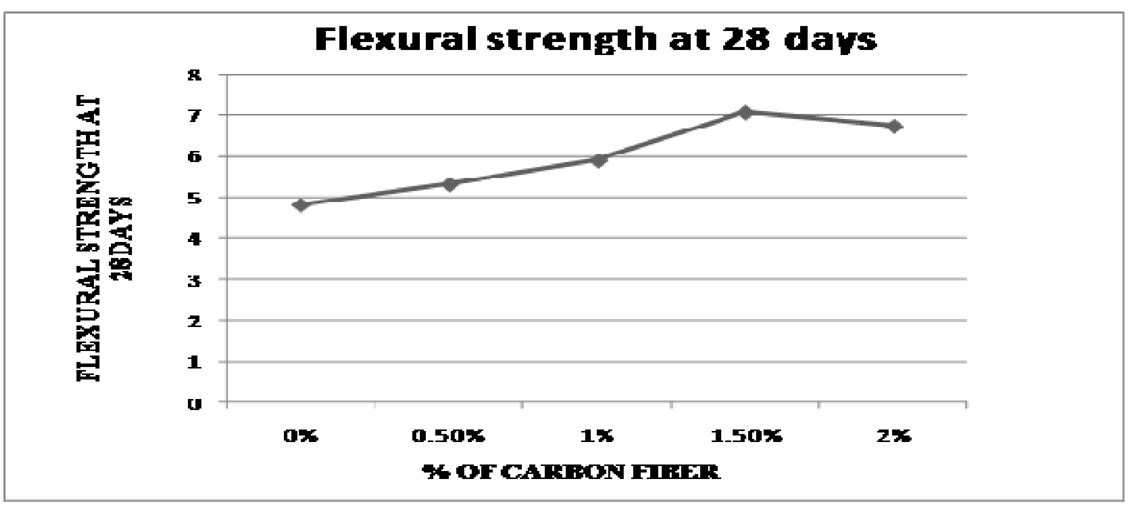



**Table 7: Flexural strength at 28 days**

| % of Carbon Fiber | FLEXURAL STRENGTH(N/mm²) | | | |
|---|---|---|---|---|
| | Sample 1 (N/mm²) | Sample 2 (N/mm²) | Sample 3 (N/mm²) | Average (N/mm²) |
| **0%** | **4.25** | **5** | **5.25** | **4.83** |
| **0.5%** | **5** | **5.25** | **5.75** | **5.33** |
| **1%** | **6.25** | **5.75** | **5.75** | **5.91** |
| **1.5%** | **7.00** | **7.55** | **6.75** | **7.08** |
| **2%** | **6.75** | **6.5** | **7** | **6.75** |




## CONCLUSION

Based on the experimental test results, following conclusions were drawn:

1. It is observed that, Compressive strength, split tensile strength and flexural strength were increased with increasing amount of carbon fiber.

2. Adding 1.5% of carbon fiber, the following improvement are observed.

3. The Compressive strength of concrete increases upto 26.23% for 28 days when compared with the conventional concrete.

4. The split tensile strength of concrete increases upto 28.98% for 28 days when compared with the conventional concrete.

5. The flexural strength of concrete increases upto 31.78% for 28 days when compared with the conventional concrete.

6. CF improves ductility of concrete member.

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