# A STUDY ON ELECTRO-MAGNETIC PROPERTIES OF CONCRETE BY USING STEEL FIBER AND GRAPHITE

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*Abstract:* This research paper describes the properties of electromagnetism of concrete mix that are sustained to make "Electrically Conductive Concrete". Thus the values provide various information on the behavior of concrete mix and its relation with electromagnetic waves. Steel fiber and Graphite are conductive materials. The properties of conductive concrete mix that is coarse aggregates, sand and cement can be measured. In the physical significance, the data calculated in X-ray diffraction and Scanning Electronic Microscope was discussed. The contact between the steel fiber and graphite is improved to make electrically conductive concrete.

***IndexTerms - Electrically conductive concrete, Electromagnetic, Steel fiber, Graphite***

## I. INTRODUCTION

Electromagnetism is that branch of physics which involves the study of electromagnetic force, a type of physical interaction that arises between charged particles only. It is a combination of all magnetic forces and electrical force. It has the properties of attraction as well as repulsion. Although the range is infinite, the force is inversely proportional to the inverse square of the distance (i.e. doubling the distance between two charged particles reduces the force between the particles by a factor of four). Electromagnetic force is carried by an electromagnetic field composed of both electric fields and magnetic fields. In addition to gravitational forces, electromagnetic forces are responsible for all forces we experience directly the other two fundamental forces that are known are the "strong forces" that hold the particles in the nucleus of an atom together. For example, electromagnetic force binds the atoms in molecules which cause friction, and attract iron to magnets. These forces are also responsible for the formation of chemical bonds between the atoms which create molecules and intermolecular forces. In addition to strong interaction, weak interaction, and gravitational interactions, electromagnetic forces are together one of the essential interactions in nature commonly called force. At high energy, weak and electromagnetic forces are combined into a single electroweak force. Electromagnetic forces play an important job in deciding the inner properties of most articles found in everyday activity.

Electrically Conductive Concrete is a cement based compound which consists of the electronic conductive elements and this provides durable and great conductivity[1]. It is widely applicable to electrical heating for melting snow from parking lots, road sidewalks, highway bridges, vehicle entrances, airport runways, and electrical grounding. Historically, it is found that concrete has existed in various forms, but there are few materials that still has exciting development opportunities[2]. For various years, many unfortunate researches made attempt to build up a concrete which can mixed with electrical conductivity properties of ordinary concrete mixtures[3]. The Construction Research Institute has been capable of achieving this demanding goal with conductive concrete. Fundamentally, aggregates frequently added in concrete that widely replaced by several carbon based material to attain the conductivity of conductive concrete. This is attained while continuing the choose engineering characteristics[4]. Generally, the conductivity is a few sets of extent higher than that of ordinary cement. Regular concrete is successfully insulating when dry and has unstable resistance properties [5].

### STEEL FIBER

During recent years, steel fiber ferroconcrete has gradually advanced from a replacement, rather unproven material to at least one which has now attained acknowledgment in numerous engineering applications. Lately it's become more frequent to

substitute steel reinforcement with steel fiber ferroconcrete[6]. The applications of steel fiber ferroconcrete are varied and widespread, thanks to which it's difficult to categorize. The foremost common applications are tunnel linings, slabs, and airport pavements[7]. Steel fibers are of many types which are used for concrete reinforcement. Round fibers are the foremost common type and their diameter ranges from 0.25 to 0.75 mm. Rectangular steel fibers are usually 0.25 mm thick, although 0.3 to 0.5 mm wires are utilized in India[8]. Deformed fibers within the sort of a bundle also are used. The most advantage of deformed fibers is their ability to distribute uniformly within the matrix [9].

*Figure 1. Steel Fibre*

**GRAPHITE**

Graphite is a crystalline form of the carbon element. Its atoms arranged in a hexagonal structure. It is the naturally occurring form of graphite. It is the most stable form of carbon under some standard condition.Under high atmospheric pressure and temperature it becomes diamond. Graphite is used in pencils as pencil lead and lubricants. Its high conductivity makes it useful in electronic conductive items such as electrodes, batteries and solar panels and as a separator materials as well as cavity materials in electromagnetic (microwave) heating applications [10-15].

*Figure 2. Graphite*

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## II. LITERATURE REVIEW

**Johnson et al., (2005):** Relative to the reinforcement of the present invention materials with fibers, whereby the fibers are oriented by an electric field. In this way, the fibers can also be concentrated, specially where this invention is subjected to stress, resulting in a significantly greater strength increase from a smaller amount of reinforcing fibers than used in conventional methods. **Peter et al., (2007) e**xposed the method of combining fiber reinforced concrete without forming fiber balls. The method includes depositing a substantially uniform layer of individual concrete reinforcing fibers on an elongated web, winding the web to include the fibers, and placing a coiled web near a concrete mixing device. And the phase of slow unraveling the web at a certain speed that the fibers are released to the layer mixer. A special package for concrete reinforcing fibers has also been revealed for use in connection with the above method. **Takazuka et al., (2009)** suggested he method of mixing steel fiber reinforced concrete includes retreating steel fibers, each having a surface weight ratio of greater than 900 mm2 / g, to orient the steel fibers in a predetermined direction and randomly orienting them.. A steel fiber penetration grid has a grid space of about 2 to 4 times the length of each of the steel fibers, thereby implying the introduction of the steel fibers into a concrete component

or unhardened concrete consisting thereof. **Akaza et al., (2010)** described **t**he method of combining steel fibers into concrete or mortar is to describe the spread and spread of the steel fiber mass. This method involves rotating the disc with radial bass on its surface, supplying a steel fiber lump in the center of the brass rotating disk, and permeatingthe steel fiber lump into smaller pieces. By extracting the mass of steel fiber at the bass, it breaks through the disk, while dispersing the expanded steel fiber, with the help of a centrifugal force caused by radial, uncoated concrete or mortar disk. **Shoop et al., (2011)** provided the structure is given, consisting of a cast, a pedestal, and a comprehensive cast with high steel fiber reinforced concrete. The fenced in area segment has dividers that form the essential security compartment. An entryway that can be moved among accessible and shut area is joined to the shaped body. The entryway is also made of high steel fiber reinforced concrete. Entryways and dividers of the shaped solid body are in any event 3 inches thick and withstand light and apparatus assaults for at any rate 15 min. High security is accommodated on cardboard and important records dwelling in the essential security cell because they are added in or distributed from the essential security compartment. **McCormack R.G. et al., (2014)** explained the apparatus for manufacturing a conductive concrete product used in electromagnetic shielding has been stated that the invention also includes a product shaped by the strategy. Solid articles framed by the strategy for the present development are fortified with charged metal filaments, ideally steel strands, with a critical segment of the strands in contact with close by strands to give electrical coherence all through the article. According to the present invention, the contact between the fibers **Ogunsola A. et al., (2018):**The protecting viability of solid structures is a central part of the engineering configuration period of a devoted control place. These structures are planned with useful necessities to suit fragile control hardware. Failing of such gear can bring about loss and effect on income administrations. This paper proposes a straightforward scientific way to deal with impact the plan of the structure so the structure appropriately weakens the adversary's electromagnetic condition and potential electromagnetic heartbeats. Correlations with numerical techniques are given.

## III. TESTING PROGRAM

For the **Compressive Strength**, the control mixtures and five conductive mixtures adding 1% steel fibers by weight of coarse aggregate and using graphite as fine aggregates replacement at the level of 0%, 0.5%, 1%, 1.5% and 2% by weight were produced in the laboratory. The water to binder ratio was chosen as 0.5. Cement content was kept at a constant of 420 $kg/m^3$ .Cylinders of 100 mm in diameter and 200 mm in height were cast for the compressive strength test. Concrete blocks were fabricated for the electrical and thermal tests.All the Specimen preparation has been conducted in an accordance with ASTM 2012. Three cylindrical specimens of 100 mm diameter and 200 mm height were prepared and tested for each mixture at the ages of 7, 14, 28 days, respectively.The alternating current voltage regulator can be used to supply a wide voltage range. In this study, four test voltage levels, 48 V, 60 V, 110 V, and 220 V, were applied. An autotransformer was connected to the electrodes of the concrete block by cables. All test voltage levels were adjusted through the autotransformer.The ampere recorder and the temperature recorder automatically record the current and temperature for every five minutes for 5 hours.**X-Ray Diffraction Analysis (XRD)**-XRD is an important method used for the quantitative and qualitative analysis of various concrete samples. The X-Ray diffraction is based on Bragg's law. By using X-Ray diffraction test results, a graph between the angle at which the wave was diffracted and intensity of X-ray was determined..

## IV. TEST RESULT AND INFERENCES

In this, the test results for the virgin sample with the additive materials in different combinations used in this study and their characteristics have been discussed. Different samples based on additives of various proportions of steel fiber in an increment of 1% and graphite in an increment of 0.5 % were obtained from Minitab Software tool to understand the effect of electromagnetic properties of Concrete to conduct X-Ray Diffraction (XRD) and SEM specially. Also, Concrete Mix design of a sample M30 grade was conducted to check out the compressive strength of sample with various proportions as-

| Stipulations for Proportions | |
|---|---|
| Grade Designation | M30 |
| Type of Cement | OPC 53 Grade |
| Max. Nominal Size | 20 mm down |
| Water Cement Ratio | 0.45 |
| Workability | 75 mm Slump |
| Concrete Placing | Manual |
| Fine Aggregate Zone | Zone 1 |
| Admixtures | Steel Fibre and Graphite |
| Specific Gravity of Cement | 2.857 |
| Characteristic Strength | 32.25 MPa |

**Compressive Strength Characteristics**

In this, the test results for the virgin sample with the additive materials in different combinations used to check out an effect for Compressive Strength of Concrete. Different samples based on additives of various proportions of steel fiber in an increment of 1% and graphite in an increment of 0.5 % were obtained

*Table 1. Compressive Strength of Concrete using Steel Fiber*

| S.No. | Mix Proportions(C:SF) | Compressive Strength(MPa) |
|---|---|---|
| 1 | 100:00 | 26.60 |
| 2 | 99:01 | 29.40 |
| 3 | 98:02 | 30.50 |
| 4 | 97:03 | 31.50 |
| 5 | 96:04 | 30.70 |
| | **Mix Proportions(C:G)** | **Compressive Strength(MPa)** |
| 1 | 99.5:0.5 | 28.25 |
| 2 | 99:01 | 29.75 |
| 3 | 98.5:1.5 | 32.89 |
| 4 | 98:02 | 30.40 |

In this world, Concrete is mostly used as a binding material with a combination of Cement with Course and Fine Aggregates. Strength, Durability and Workability are the main advantages. Due to weak tensile strength, Concrete is generally reinforced with Steel for its strength increment. That is the reason; Steel Fibers represent a considerable improvement in the strength of Concrete. M30 Grade of Concrete has been used with 1% increment of Steel Fibers to check out the strength. From Table 1,Out of all the prescribed results, there is an effective increase of Compressive Strength up to 3% Steel Fiber, After than there will be a decrement in the Strength due to the fact that higher fiber content may causecongestion of fibers, thus resulting in balling effect and improper bonding with concretewhich represents 3% as an optimum value with Steel Fiber .Also,From the Table 2, It has been observed that

Compressive Strength will increase with an increasing amount of Graphite. Initially, up to 1.5% of Graphite, Compressive Strength will increase but at 02% Content, it will be decreased due to a closed packing of particles to fill up the voids.

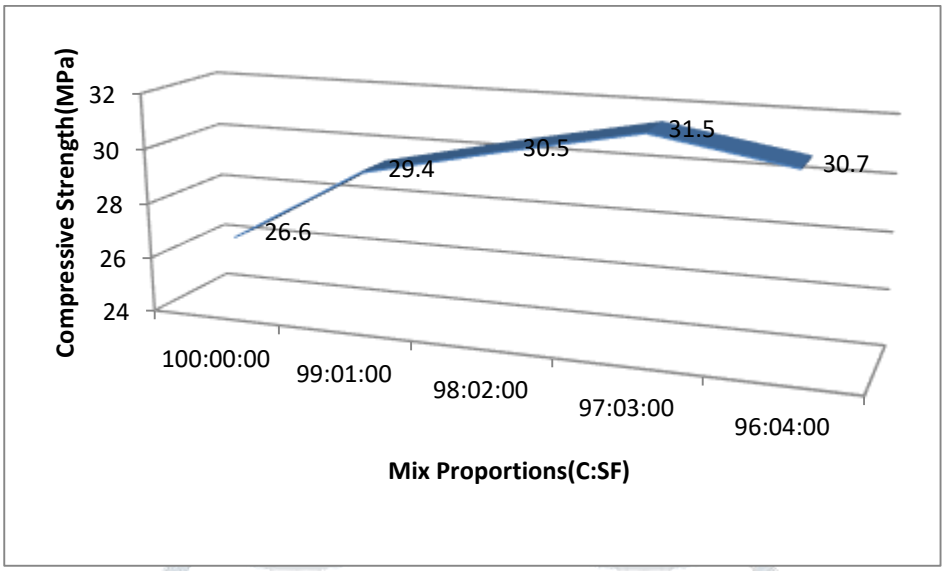


*Figure 3. Represents an effect of Steel Fiber on Compressive Strength of Concrete*

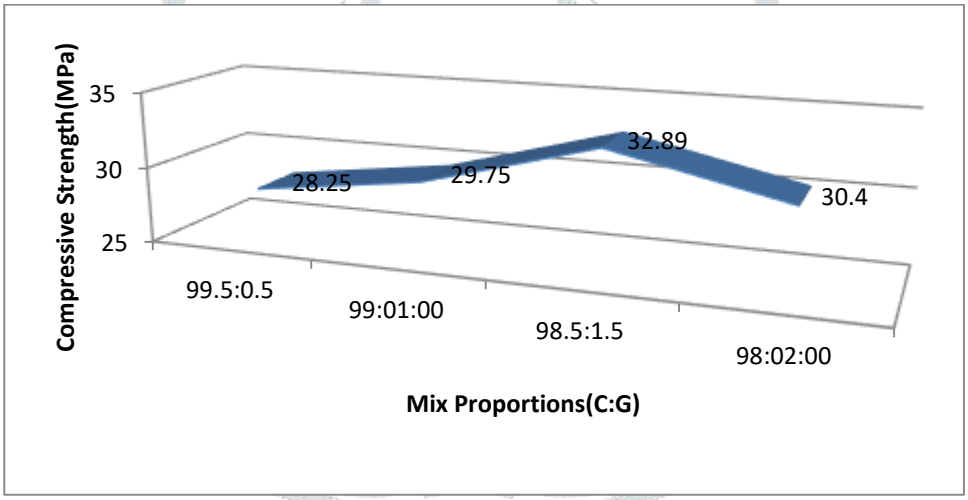


*Figure 4. Represents an effect of Steel Fiber on Compressive Strength of Concrete*

**Comparison of reference sample with XRD Analysis**

XRD is generally used for hydration like calcium silicate hydrate (C-S-H), calcium aluminosilicate hydrate (C-A-S-H), portlandite ($Ca(OH)_2$) and ettringite present in the concrete.Fig.5 represents the intensity of calcium hydroxide ($Ca(OH)_2$) in the presence of C-A-S at $2\theta = 20.64$ will increase due to water binder ratios. Formation of $Ca(OH)_2$ is more in normalconcrete compared to XRD concrete.The peak intensity of calcium silicate hydrate at $2\theta=26.46$ has increased more in the presence of XRD Concrete compared to a Normal Concrete and the intensity of calcium aluminosilicate hydrate is more in normal concrete at $2\theta=28.29$ which learly indicates a rapid hydration

*Table 2 XRD Analysis of Concrete using Steel Fibre and Graphite*

| S.No. | Mix Proportions(C:SF:G) | 2-Degree Values |
|---|---|---|
| 1 | 98.5:01:0.5 | 20.64 |
| 2 | 98:01:01 | 22.87 |
| 3 | 97.5:01:1.5 | 26.46 |
| 4 | 97:01:02 | 28.29 |

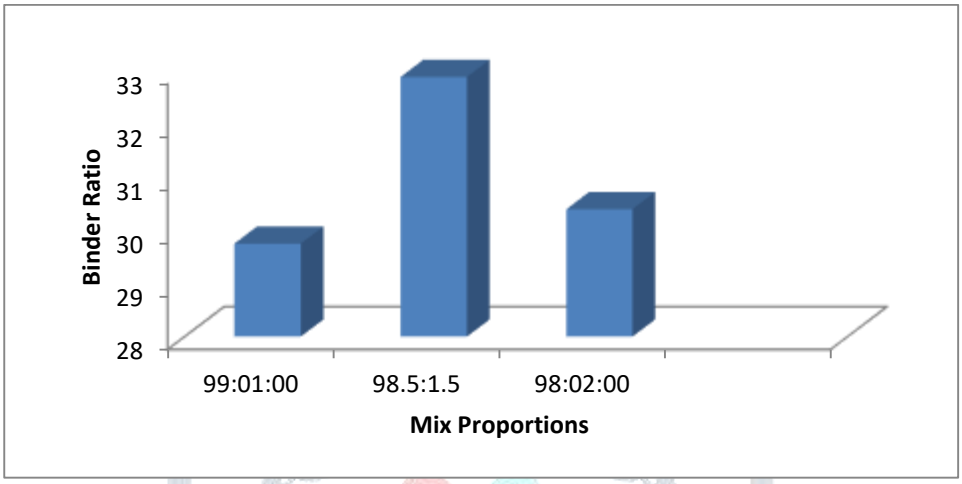


*Figure 5. Represents SEM Analysis of Concrete with Steel Fibre and Graphite*

## IV. CONCLUSIONS

An investigational study on the role of the electromagnetic properties of Concrete on various proportions of graphite and steel fibre was carried out XRD and Compressive Strength Analysis. Different Water Cement Ratio was used. The hydration of the pastes was also simulated in a microstructural modeling platform with various experimental results.

The main conclusions from this study are listed below:

1. With the increase in fibre content, the compressive strength also increases. The strength is gained continuously till 3% where the maximum strength is gained which is 9.77% higher than the strength achieved by controlled sample. The control sample achieved 26.60MPa, with addition of 1% steel fibers the concrete achieved 29.40MPa, further increase in steel fibre content to 2% gained higher strength of 30.50MPa. The maximum compressive strength of 31.50MPa was achieved with the addition of 3% steel fibres. Further increase in steel fibre content resulted in decrease in strength, though 4% steel fibre reinforced concrete achieved 30.70MPa
2. It has been observed that XRD Analysis provided an effective implementation in the process of Cement hydration
3. Relation between the early age strength development and the heat released from hydration was found. In the long-term as well, the degree of hydration measured using chemical shrinkage related well with the strength development of the electromagnetic properties
4. Due to a property of Graphite as a good conductor of electricity, it plays an important role to increase electromagnetic properties of Concrete

## V. FUTURE SCOPE

In the Present Study, it has been concluded that Steel Fiber and Graphite are good additives to check out the electromagnetic properties of Concrete. But, their effect on other properties can be carried out as a future scope. These are-

1. An effect of steel fibre on Mortar's pore size distribution
2. Characteristics of Hydration on effect of Graphite
3. Temperature and Replacement level for electromagnetic properties.

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