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Concrete Structure by Using Carbon Nanotube and Its Use to Monitor Its Structural Health

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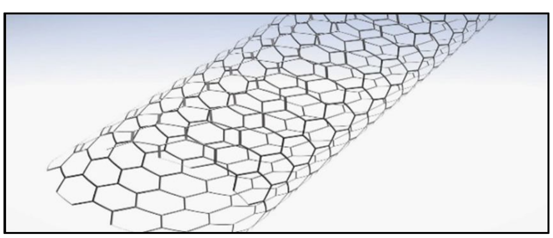
Abstract: Cementitious materials doped with carbon nanoparticles are robust materials that can convert stress into changes in electrical resistance. These properties encourage the development of spatially distributed sensors for structural health monitoring of concrete structures. However, very few applications of cement-based nanocomposite transducers to structural elements have been documented. Most applications are limited to measuring static reactions. CNTs could effectively arrest crack propagation, increase joint rigidity, and reduce deformation of concrete corbels between steel ribs. Higher aspect ratio CNTs could make a better contribution with their micro crack bridging effect. Microscopic analysis confirmed the adequate distribution and bridging of micro cracks by CNTs and delayed the propagation of macro cracks within the transition zones between aggregate and reinforced concrete
Keywords: carbon nanotube, nanoparticle, stress, structural health monitoring,sensor

I. INTRODUCTION

The structural health monitoring of concrete is being important in now a days. So taking of structure with proper maintenance and safety is being the first priority. In these project we made an concrete sample with carban nantube which further used to check the structural health monitoring of an concrete structure.
Carbon nanotubes (CNTs) are novel Nano carrier systems that have a wide range of applications in science, engineering, and, the environment. Owing to the possible functionalization of CNTs (i.e., surface-engineering of the nanotubes) with certain chemical groups their physical or biological properties can be manipulated for various applications. In addition to the ability of CNTs to act as carriers for a wide range of therapeutic molecules, their large surface area and possibility to manipulate their surfaces and physical dimensions have been exploited to use them in thermal conductivity.

There are mainly two types of carbon nanotubes:
1) Single-walled Carbon Nanotubes
2) Multi-walled Carbon Nanotubes



F ig.1.2 Single Walled Carbon Nanotube

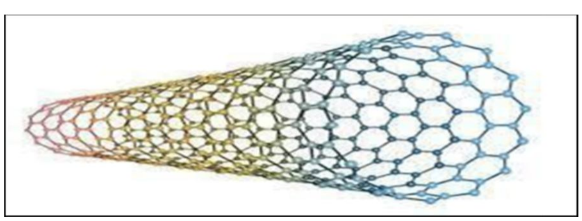


Fig.1.2 multi Walled Carbon Nanotube

A. Carbon Nanotubes Applications

1) *Chemical Applications:* It is helpful in gas sensors as it is sensitive to gases such as H2, NO2, O2, or NH3, dielectrics. It is also beneficial in field-emission displays and photovoltaic. It also acts as unique catalyst support in chemical processes.
2) *Fibers and Fabrics:* Displaying immense strength helps make bulletproof vests and armors, transmission line cables, stain-resistant fabrics, etc.
3) *Composite of Structures:* It displays excellent mechanical properties such as toughness, strength, and stiffness. It is used in various compositions of various structures such as wind turbines, marine paints, composite polymers, and many more.
4) *Energy:* It helps make another energy powerhouse, field-effect transistors, solar cells, reusable batteries, electrical wires, and cables.

II. LITERATURE REVIEW

1) Hawreen J. A. Bogas (2018)–"Influence of carbon nanotubes on steel–concrete bond strength" In this study, the bond strength between steel and concrete reinforced with multi-walled carbon nanotubes (CNTs) is analyzed. The results showed that CNTs can improve both compressive strength and steel– concrete bond up to 21% and 14% respectively, as compared to plain concrete.For CNTs-reinforced concrete, five types of industrial multi-walled CNTs were selected from thattwo CNTs are used that is CNTSL and CNTSS.
2) Waqas Latif Baloch, Rao Arsalan Khushnood et.al (2018)–"Influence of multi-walled carbon nanotubes on the residual performance of concrete exposed to high temperatures" Residual mechanical properties of lightweight concrete (LWC) and normal strength concrete(NSC) containing multi-walled carbon nanotubes (MWCNTs) after exposure to high temperaturesare presented. Mechanical properties such as compressive strength (f'c,T), tensile strength (f't,T), stress-strain response, compressive toughness (Tc) and mass loss of the analyzed formulations werestudied and have been elaborately discussed.
3) Filippo Ubertinia, Annibale Luigi Materazzia, et.al (2014) Natural frequenciesidentification of a reinforced concrete beam using carbon nanotube cement-based sensors,, In this paper, the use of composite cementitious sensors with carbon-nanotubes has been proposed for vibration monitoring of RC structures. In this paper, the use of composite cementitious sensors with carbon-nanotubes has been proposed for vibration monitoring of\ RC structures.
4) Hawreen, J. A. Bogas et.al, (2019) – Mechanical Characterization of Concrete Reinforced with Different Types of Carbon Nanotubes Most stable dispersions were found in the 5–10 Ph range. Lower aspect ratio CNT had lower structural damage after sonication and higher dispersion capacity in alkaline environments (high PH) than longer CNT. Difference in CNT's properties, amount and dispersion procedur leads to variable concrete performances
5) Myungjun Junga Young-soon Leeb Sung- Gul Honga Juhyuk Moon (2019) – Carbon nanotubes (CNTs) in ultra-high performance concrete (UHPC): Dispersion, mechanical properties, and electromagnetic interference (EMI) shielding effectiveness (SE) In this paper, Ultra-High Performance Concrete (UHPC) was investigated with regard to the dispersion, mechanical properties, and electromagnetic shielding effectiveness (SE). Dispersed CNT solution (0–2.0 wt %) was prepared by sonication and subsequent shear mixing with super plasticizer to achieve the high flow ability for UHPC slurry. Dispersed CNTs can improve the mechanical properties of (UHPC) Dispersed CNTs can remarkably improve the electrical conductivity of UHPC up to the percolation threshold
6) A. Hawreen. J. A. Bogas "Creep, shrinkage and mechanical properties of concretereinforced with different types of carbon nanotubes" (2019) The incorporation of 7 different CNTs lead to similar long term shrinkage behavior only CNTOHand CNTSL where ineffective in shrinkage reduction. The lowest decrease of total shrinkage wasfound in water cement concrete and for higher amount of CNTs.

III. MATERIAL USED

A. Cement

A cement is a binder, a chemical substance used for construction that sets, hardens, and adheres to other materials to bind them together.

Cement is seldom used on its own, but ratherto bind sand and gravel (aggregate) together. Cement mixed with fine aggregate produces mortar for masonry, or with sand and gravel, produces concrete. Concrete is the mostwidely used material in existence and is behind only water as the planet's most-consumed resource.

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Fig.No.3.1) Cement

B. Sand

Sand is a granular material composed of finely divided mineral particles. Sand has various compositions but is defined by its grain size. Sand grains are smaller than gravel and coarser than silt. Sand can also refer to a textural class of soil or soil type; i.e., a soil containing more than 85 percent sand-sized particles by mass.

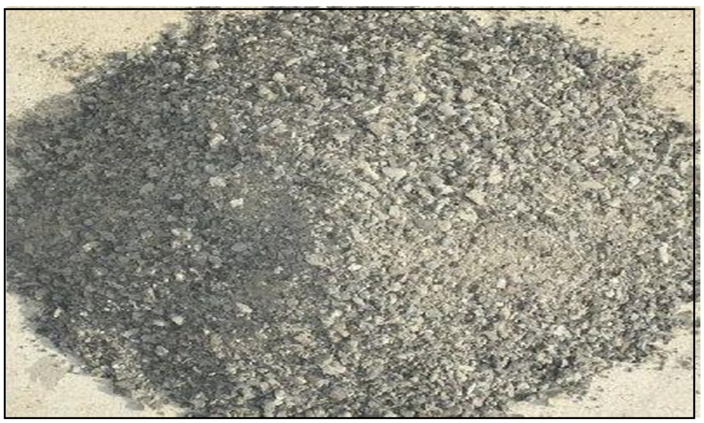

Fig.No.3.2) Sand

C. Aggregate

Aggregate, is a broad category of coarse- to medium-grained particulate material usedin construction, including sand, gravel, crushed stone, slag, recycled concrete and geosynthetic aggregates. Aggregates are the most mined materials in the world. Aggregates are a component of composite materials such as concrete and asphalt; the aggregate serves as reinforcement to add strength to the overall composite material. Due to the relatively high hydraulic conductivity value as compared to most soils, aggregates are widely used in drainage applications such as foundation and French drains, septic drain fields, retaining wall drains, and roadside edge drains.

Fig.No.3.3) Aggregate

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D. MWCNT

Multi Walled Carbon Nanotubes (MWCNTs) is nothing but multiple graphene layers rolledup into hollow concentric tubes. It is a one-dimensional by-product of graphene and an allotrope of carbon with sp2-hybridized carbon bonds. The single walled carbon nanotubes (SWCNT) isa single layer of graphene sheet rolled up to form a tube-like structure. The difference betweenSWCNT and Multi Walled Carbon Nanotubes is that MWCNT has multiple layers of walls combined. A variant of the same is double-walled carbon nanotubes which have only two walls.

Fig.No.3.4) Carbon Nanotube

E. Deionized Water

Deionized water, or DI water, is sometimes called demineralized water, or DM water. It is water which has had (most of) the ions removed. Ions are atoms or molecules which have either moreelectrons than protons, making a negative ion (an anion) or fewer electrons than protons, making a positive ion (called a cation).

Fig.No.3.5) Deionized Water

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F. Electrodes

An electrode is an electrical conductor used to make contact with a nonmetallic part of a circuit (e.g. a semiconductor, an electrolyte, a vacuum or air). Electrodes are essential partsof batteries that can consist of a variety of materials depending on the type of battery. The electrophori, invented by Johan Wilcke, was an early version of an electrode used tostudy static electricity.

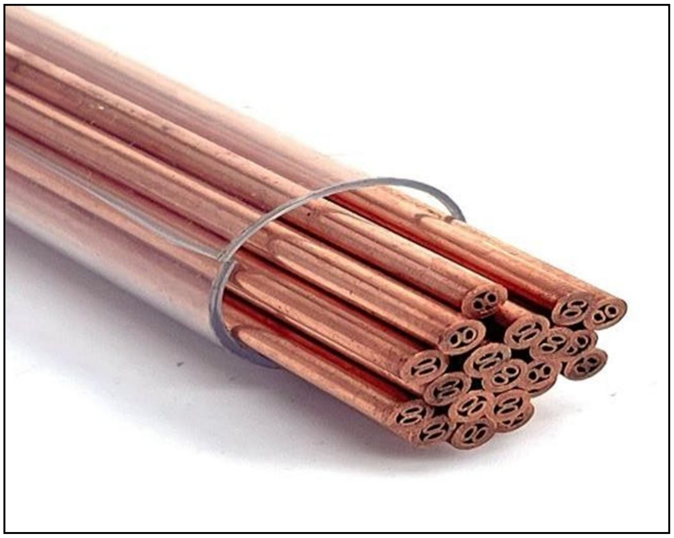

Fig.No.3.6) Electrodes

G. Plasticizer

The essence of good quality concrete is the requirement of right workability. Under different situations concrete of different degree of workability is needed. A high degree of workability isrequired in situations like deep beams, thin sections with high percentage of reinforcement, beam and column junctions, pumping of concrete, termite concreting, hot weather concreting etc. The conventional methods of improving workability are by improving the gradation or increasing the quantity of fine aggregate or by increasing the cement quantity.

Fig.No.3.7) Plasticizer

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IV. EXPERIMENTAL PROCEDURE

A. *Preparation of Solvent*

In that water, plasticizer and MWCNT are mixing in properly with the help of magnetic stirring. The primary use of magnetic stirrer or hot plate with magnetic stirrer is to conduct biological andchemical experiments by mixing two components. It is equally suitable for solids or liquid samplesto obtain a consistent liquid mixture. The capacity of magnetic stirrer that we use is 2 LTR in thatwe use deionized water and addition of MWCNT powder for create the homogenous mixture.

Fig.No.3.8) Deionized Water

Fig.No.3.9) Plasticizer

Fig.No.3.10) Magnetic Stirring

B. Sonication

After the making homogeneous mixture with the help of magnetic stirrer, sonication will be carried out. Sonication is the most important process in the preparation of Nano fluids. Sonication is carried out in an ultra-sonication path, ultrasonic vibrator, and mechanical homogenizer. Apart from sonication frequency and power, sonication time is the most crucial part of the process. Stability of the prepared Nano fluid is greatly dependent of the time of sonication. Sonication – ultrasound sonication with hot bath has been used with certain voltages with defined time frame.

Fig.3.11) Sonication Performance

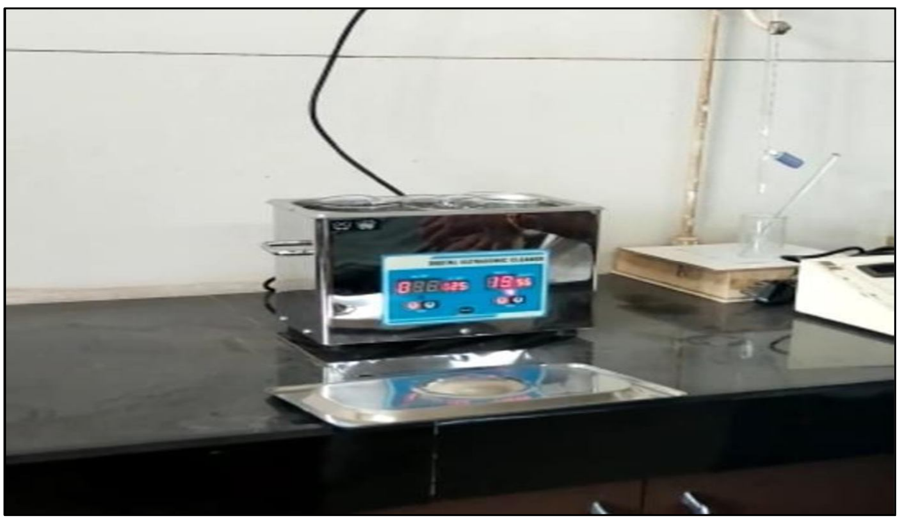
Fig.3.12) Sonication Machine

C. *Casting of Concrete*

For the casting of beam the quantity of material that required is -M25 grade of concrete is used (1:1:2) proportion.

Table No: 3.1) Quantity of material

Material	Quantity/Specimen
Cement	5.39 kg
Sand	5.39 kg
Aggregate	10.78 kg
Water	2.42 lit

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Fig.No.3.13) Dry Mixing

Fig.No.3.14) Casting of concrete

D. *Electrodes Placement*

After the casting of concrete, copper electrodes are embedded in middle portion at a spacingof 10 MM each.
For comparison purpose a normal beam was casted in same quantity of material.

Fig.No.3.15) Placing Electrodes

E. *Unmoulding and Curing*

After the setting of concrete unmoulding the beam and curing it.

Fig.No.3.16) Curing of Beam

Fig.No.3.17) Curing of Beam

Fig.No.3.18) Beam with CNTS

Fig.No.3.19) Normal Beam

F. Testing on Concrete with MWCNT and Normal Concrete

1) For the testing of concrete with MWCNT the concrete specimen placed on the mechanical vibrator.
2) Then the arrangement made which include placing of alarming vibration sensor on top of the specimen.
3) Then the sensor is connected to the digital oscilloscope with the help of wires.
4) Then the power supply to connected to sensor and as well as to the DSO.
5) After that the vibrator is started and then with the help of DSO and sensor we get the results in terms of HZ.

V. RESULTS

SR NO		Vibration test results taken by vibration sensor and digital storage oscilloscope on concrete with MWCNT (In Hz)	Vibration test results taken by vibration sensor and digital storage oscilloscope on concrete (In Hz)
1	Result no 1	184 HZ	164HZ
2	Result no 2	160 HZ	839.4 HZ
3	Result no 3	90 HZ	671 HZ
Mean values in HZ		144.66	558.13

Fig.no. 4.1 experimental setup

Fig.No.4.2 Accelerometer

Fig.No.4.3 Vibration

VI. CONCLUSION

Past research paper we referred the use of composite cementitious sensors with carbon-nanotubes has been proposed for vibration monitoring of concrete structure they have not taken it on the reinforced concrete structure. So we took the test on reinforced concrete specimen with embedded carbon nanotube.

Post construction while performing vibration analysis on concrete and we have found significant frequency difference analyzed under table vibration which concludes MWCNTs is more sustainable and stable to the vibration variable. Hence further test about different variable has to be performed. Hence in future for the result accuracy data acquisition system should use with proper arrangement for the close observation and to know any other test are also required in future for improvement of the project.

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