e-ISSN: 2582-5208
International Research Journal of Modernization in Engineering Technology and Science
(Peer-Reviewed, Open Access, Fully Refereed International Journal)
Volume:05/Issue:10/October-2023 Impact Factor- 7.868 www.irjmets.com

STUDY OF CARBON NANOTUBES ON COMPRESSIVE AND SPLIT TENSILE STRENGTH OF CEMENT BASED CONCRETE

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ABSTRACT

Carbon Nanotubes (CNTs) are one of Nanomaterial. Nanomaterial are so small that 150,000 of them fit across the width of a strand of human hair. Generally, nanoparticles involve the range of 1-100nm .It is also considered as the size effect technology in which different properties gets changed due to the dimension scale. With the help of nanotechnology, the same material gets different applications as per the dimension level. Carbon Nanotubes are of two types namely single-walled nanotube and multiple walled nanotube.The paper discuss with the review of Carbon Nanotube (CNT) from various literature which are integrating Carbon Nanotube in cement concrete on strength characteristics. Concrete is a construction material composed of cement, fine aggregates (sand) and coarse aggregates mixed with water which hardens with time. Cement is made up of four main compounds: tricalcium silicate ($3CaO \cdot SiO_2$), dicalcium silicate ($2CaO \cdot SiO_2$), tricalcium aluminate ($3CaO \cdot Al_2O_3$), and a tetra-calcium aluminoferrite ($4CaO \cdot Al_2O_3Fe_2O_3$). At a microscopic level, calcium silicate hydrate can be seen as a cloud like structure were calcium hydroxide is like a rose made of stone like petals and calcium sulfur-aluminates hydrates produce ettrigite i.e. a needle like structure. Even though it is observed that there are different types of shapes inside the structure, the voids are still present. It is one major cause for the weakening of the strength in concrete. Thereby, nanotubes are used to fill in these voids that could be observed at nano-scale. Hence the strength of cement concrete increased.

Keywords: Cement Concrete, Carbon Nanotube, Strength, Single-Walled Nanotube, Multiple Walled Nanotube.

I. INTRODUCTION

In case of concrete (a mixture weak in tension and strong in compression), more than 2 tons per person are produced annually. Quantitatively, more than 11 billion metric tons are consumed every year all over the world. The cement industry is responsible for approximately 5–8% of all anthropogenic emissions of carbon dioxide worldwide. In order to improve concrete properties, a series of nanomaterials can be applied, such as nanoengineered polymers, superplasticizers, high strength fibers, or silicon dioxide. Carbon nanotubes (CNTs), well known for having extraordinary properties, are considered as major candidates for diverse applications in nanotechnology. CNTs have been incorporated into materials for cement production, with excellent results, upon low quantities of added material.

Carbon nanotube is a hollow tube made up of carbon of nanoscale diameter. In short, it is represented as CNTs. Carbon nanotubes are also called buckytubes.

‘Nanotubes are formed by folding or rolling two-dimensional graphite into a cylindrical shape structure. Nanotubes are hollow from inside. The diameter of the nanotube is around 1-3 nanometres. The length of the carbon nanotube is much higher than its diameter. Nanotube length generally goes to a few micrometres. In short, we can say that carbon nanometre (CNT) is a folded form of the two-dimensional graphene sheet.

Carbon nanotubes are classified into two category -Single walled nanotubes and multi walled nanotubes.

Single-walled Carbon Nanotubes- It is represented as SWCNT. The Single-walled Carbon nanotubes exist in a 1-d structure. Some examples of Single-walled CNT are armchair and zig-zag Single-walled Carbon nanotubes.

- The diameter of Single-walled Carbon nanotubes is 2nm.
- The length of Single-walled Carbon nanotubes is around 2 micrometres.
- They exist in a one-dimensional structure. Therefore, it is also known as a nanowire.

- Electronics can be miniaturized by using a Single-walled Carbon nanotube.
- Their band gap varies from 0-2 electron volts (eV).
- They show conductivity like a semiconductor. Therefore, they exhibit both metallic and semi conductivity behaviour.

Multi-walled Carbon Nanotubes- It is represented as MWCNT. It is composed of several nested carbon nanotubes. This type of nanotubes has two diameters, one is known as outer diameter and another one is known as inner diameter. An example of Multi-walled Carbon nanotubes is chiral Multi-walled Carbon nanotubes.

Properties of Multi-walled Carbon Nanotubes are given below:

- The outer diameter of Multi-walled Carbon nanotubes is around 2-20 nanometres.
- The inner diameter of Multi-walled Carbon nanotubes is 1-3 nm.
- The length of Multi-walled Carbon nanotubes is around 5-6 micrometres.

II. LITERATURE REVIEW

Valentin et al. (2004) The Carbon nanotubes are unique tubular structures of nanometer diameter and large length/diameter ratio. The amazing mechanical and electronic properties of the nanotubes stem in their quasi-one-dimensional (1D) structure and the graphite-like arrangement of the carbon atoms in the shells. Thus, the nanotubes Have High Young's modulus and tensile strength, which makes them preferable for composite materials with Improved mechanical properties.

Gogotsi., Nanomaterials handbook Taylor & Francis Group (2006) found that the contribution of nanotubes to the 20% increase in Young's modulus found for the nanocomposite films with a loading of only 0.2% of SWNTs.

Saurav et al. (2012) Analysis stated that the application of nanotechnology in building materials for various civil engineering works. The use of nanotechnology controlled the matter at the atomic level; the properties of matter were seriously affected strength, durability and other properties of materials are dramatically affected under a scale of nano meter (10-9m). The use of nano technology makes concrete stronger, durable and more easily placed.

Jayshree et al (2013) conducted a review on the effect of multiwall carbon nanotubes (CNT) on strength characteristics and durability of concrete. They tested and conducted Sonication process by adding MWCNT with surfactants, in water with 36 Specimens in cement at 28 days of curing. After 28 days of curing the results showed an increase in compressive and splitting-tensile strengths of the samples with increasing MWCNT. As a result, Crack propagation was reduced and water absorption was decreased by 17% at 28 days curing. They noticed that by increasing the percentage of functionalized MWCNT to concrete, the water absorption was reduced to a greater extent which helped in improving the concrete to be more durable and water resistant.

Abhinayaa (2014) investigated and understood that the increasing the proportions of functionalized MWCNT into concrete increases the compressive strength. In fact, the compressive strength of the concrete with a proportion of 0.045% of functionalized MWCNT increases by 26.69%. the split tensile strength increased by 66.3% for 0.045% of MWCNT. With increase in MWCNT, the rate of increase of the tensile strength is greater than that of the rate of increase of the compressive strength.

Mohamed O. Mohsen, Mohamed S. AL Ansari, Ramzitaha, Nasser AL Nuaimi, and Ala Abu Taqa, Oct 2019.

In this paper author concluded that high CNT contents of 0.15 and 0.25 wt.% CNTs would increase the flexural strength of concrete by more than 100%.and also CNTs would increase the ductility of concrete by about 150%. The permeability coefficient decreased by at least 45% when CNTs were added to concrete. The addition of CNTs to concrete resulted in a denser composite with higher flexural strengths and strain capacity and lower permeability when compared to plain concrete.

Heba A. Gamal (2021) analyses the efficiency of CNTs. They used 15% of nano clay and 0.01%, 0.02% and 0.04% of CNTs by weight with the mix. Different tests are carried out such as air content, workability, compressive strength test, tensile strength test, flexural strength test, sorptivity, water penetration test, chloride penetration test, corrosion resistance and scanning electron microscope (SEM). The test result is

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concluded that increase in bond strength, slight increment in sorptivity, increment trend in chloride penetration, hybrid nanoparticles improve the corrosion resistance and enhancing the durability properties.

III. METHODOLOGY

As the most widely used construction material, concrete has taken our civilization forwards for centuries. However, concrete structures may be subjected to various environmental threats including erosion, impact forces, and harsh weather conditions. Excessive exposure to such adverse environmental conditions could induce cracking and delamination of concrete, leading to potential long-term safety concerns.

The objective of this paper is to appropriately use Multi-walled Carbon Nanotubes in concrete. MWCNTs are predominantly used because of their lower prices as well as easier dispersibility compared with SWCNTs. The addition of carbon nanotubes increases compressive strength, flexure tensile strength, frost resistance of concrete, permeability and the galvanic coupling effect between steel reinforcement bars and nanotubes.

The major challenges for using CNT in cement concrete is uniform dispersion of CNTs in cement matrix, which is very difficult to achieve because of van der Waals forces. Individual CNT has a tendency to adhere to each other because of this force. CNTs because of their hydrophobicity, lack of solubility present great challenge in mixing effectively in cement matrix. The very high specific surface area of CNTs poses a problem in dispersion because they tend to reunite and bundle up owing to the high surface energies particularly in the case of MWCNTs. Also, even the effectively dispersed CNTs pose a problem of adhesion since it has been observed that finely dispersed MWCNTs are pulled out of the matrix under tension because of the lack of adhesion. Commercial grade MWCNT was procured in powder form. Therefore, ultrasonic vibration was utilized to split agglomeration of nanotubes and distribute them across the cement grains. Dispersion of Carbon nanotubes is very important for addition into the concrete. For this experiment dispersion of carbon nanotubes is done by Bath So nicator. Dispersion of CNT is done in water. These samples are placed in ultrasonic bath for 30 minutes after that samples are removed and cooled to room temperature. Compressive strength of concrete reinforced by carbon nanotubes increased because size of carbon nanotubes is very small which cement as well as a decrease in the cement matrix's porosity and holes. Tensile strength of carbon nanotubes is 400 times stronger than steel so it increases tensile strength of carbon nanotubes. The toughness of concrete reinforced by carbon nanotubes increased due to high thermal stability.

IV. CONCLUSION

It can be comprehensively reviewed that the feasibility of developing new cements reinforcing with carbon nanotube large increases in flexural strength and in compressive strength, along with a reduction in porosity. To develop high performance, multifunctional, ideal (high strength, ductile, crack free, durable) construction material, carbon nanotubes (CNTs) show promising role to modify/enhance the characteristics of the conventional construction materials such as concrete and steel. For get better result we increase sonication period from 30 min to 50 min.

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