A STUDY ON CARBON NANOTUBE (CNT) IN CONCRETE

Dr. B.VIDIVELLI[1], B.ASHWINI[2]

[1]*Professor, Department of Civil & Structural Engineering, Faculty of Engineering and Technology, Annamalai University, Chidambaram, Tamil Nadu.*

[2]*Research Scholar, Department of Civil & Structural Engineering, Faculty of Engineering and Technology, Annamalai University, Chidambaram, Tamil Nadu.*

---***---

Abstract - *This paper discuss with the review of Carbon Nanotube (CNT) from various literature which are integrating Carbon Nanotube as 0.15% to 2.5% on strength characteristics and durability of the concrete. Sonication process is carried out by adding the CNT with surfactants by weight of cement or water. It is obtained from the various literature explains ultrasonic dispersion techniques were adopted to disperse them uniformly. Tensile, compressive strength, durability and bending tests have been conducted on the specimens in the past experimental program. This paper presents the methodologies and results in reference to various research papers on similar experiments. Moreover, This paper is discussed based on to enhance the above given properties.*

Keywords — Concrete , Carbon nanotube (CNT) , Sonication process , Compressive Strength , Tensile Strength , Durability.

1. INTRODUCTION

Concrete is the solid composite material and made up of suitable proportion of binding material, fine aggregate, Coarse aggregate and Water. And also it is mainly used to make driveways, patios, roads, bridges, and even entire buildings. The artificial stone called concrete is the most widely used building material. It is created by mixing aggregate, cement and water. In modern construction, we need advanced admixtures to be enhancing their properties of concrete. Which means to be mostly avoid the cracks, shrinkage, and also creep in the structures. The recent researches on nanomaterial's and nanotechnologies have highlighted the potential use of these materials in various fields such as medicine, construction, automobile industry, energy, telecommunications and informatics. This is due to the special characteristics of materials at the nano scale. Building materials domain can be one of the main beneficiaries of these researches, with applications that will improve the characteristics of concrete, steel, glass and insulating materials. Improving the materials resistances and the increasing of their durability will reduce environmental pollution by reducing the carbon footprint of the building. Nanomaterial's can be defined as those physical substances with at least one dimension between

1…150 nm (1 nm = 10^{-9} m). The nanomaterial's properties can be very different from the properties of the same materials at micro (10^{-6} m) or macro scale (10^{-6}…10^{-3} m). The nano-science represents the study of phenomena and the manipulation of materials at nanoscale and is an extension of common sciences into the nanoscale. The nanotechnologies can be defined as the design, characterization, production and application of structures, devices and systems by controlling shape and size at the nanoscale. Nanotechnology requires advanced imaging techniques for studying and improving the material behavior and for designing and producing very fine powders, liquids or solids of materials with particle size between 1 and 100 nm, known as nano-particles **(Gogotsi, 2006).** Currently, the use of nanomaterials in construction is reduced, mainly for the following reasons: the lack of knowledge concerning the suitable nanomaterials for construction and their behavior; the lack of specific standards for design and execution of the construction elements using nano-materials; this nano materials have four types which are using for concrete **Nano silica, carbon nanotube, titanium, carbon fiber** the reduced offer of nanoproducts; the lack of detailed informations regarding the nanoproducts content; high costs; the unknowns of health risks associated with nanomaterials.

In order to be able to use in the construction industry the nanomaterials at wide scale it is necessary that the researches to be conducted following the next stages: the choice of nanomaterials with potential use in construction and the study of their characteristics; the behavior study of the building elements that contain nanomaterials under various loads; the development of specific design and construction standards. This paper is part of the first stage of research and represents a synthesis of nanomaterials proper to be used in construction.

1.1 Nanomaterials for Construction

The size of the particles is a critical factor, the material properties significant differ at the nanoscale from that at larger scales. Physical phenomena begin to occur differently below the boundary limit: gravity becomes unimportant, electrostatic forces and quantum effects start to prevail. In the same time, the proportion of atoms on the surface increases relative to those inside, creating so-called **"nano-effect"**. All these nano-properties actually affect the materials behavior at macro-scale and, from this point, the power of nanotechnology is emphasized: if the elements are proper manipulated at the nanoscale, the macro-properties are affected and new materials and processes can be developed **(Ge & Gao, 2008)**. In what follows the most important nanomaterials with potential use in construction are presented.

1.2 Application of Nanotechnology in Concrete

1.2.1 The Carbon Nanotubes

Carbon nanotubes are seamless, carbon cylinders which have unique mechanical and electronic properties. Carbon nanotubes are a form of carbon having a cylindrical shape, the name coming from their nanometre diameter. They can be several millimeters in length and can have one "layer" or wall (single walled nanotube) or more than one wall (multi walled nanotube) **(Lu et al., 2010).** Nanotubes are members of the fullerene structural family and exhibit extraordinary strength and unique electrical properties, being efficient thermal conductors. For example, they have five times the Young's modulus and eight times (theoretically 100 times) the strength of steel, whilst being 1/6th the density. Expected benefits of carbon nanotubes are: mechanical durability and crack prevention in concrete enhanced mechanical and thermal properties in ceramics and real-time structural health monitoring capacity **(Mann, 2006).**

1.2.2 Titanium Dioxide Nano particles (TiO_2)

The titanium dioxide nanoparticles are added to concrete to improve its properties. This white pigment is used as an excellent reflective coating. or added to paints, cements and windows for its sterilizing properties. The titanium dioxide breaks down organic pollutants, volatile organic compounds and bacterial membranes through powerful photocatalytic reactions, reducing air pollutants when it's applied to outdoor surfaces. Being hydrophilic gives self cleaning properties to surfaces to which it is applied, because the rain water is attracted to the surface and forms sheets which collect the pollutants and dirt particles previously broken down and washes them off. The resulting concrete surface has a white colour that retains its whiteness very effectively **(Mann, 2006).**

1.2.3 Silicon Dioxide Nanoparticles (SiO_2)

Nano-SiO2 could significantly increase the compressive strength of concretes containing large fly ash volume at early age, by filling the pores between large fly ash and cement particles. Nano-silica decreases the setting time of mortar when compared with silica fume (microsilica) and reduce bleeding water and segregation by the improvement of the cohesiveness **(Sadrmomtazi & Barzegar, 2010)**

1.2.4 Nanotechnologies for Concrete

Concrete is a macro-material strongly influenced by its nano-properties. The addition of nano-silica (SiO_2) to cement based materials can control the degradation of the calcium-silicate hydrate reaction caused by calcium leaching in water, blocking water penetration and leading to improvements in durability **(Mann, 2006).**

Nano-sensors have a great potential to be used in concrete structures for quality control and durability monitoring. (to measure concrete density and viscosity, to monitor concrete curing and to measure shrinkage or temperature, moisture, chlorine concentration, pH, carbon dioxide, stresses, reinforcement corrosion or vibration). Carbon nanotubes increase the compressive strength of cement mortar specimens and change their electrical properties which can be used for health monitoring and damage detection. The addition of small amounts (1%) of carbon nanotubes can improve the mechanical properties of mixture samples of Portland cement and water. Oxidized multi-walled nanotubes show the best improvements both in compressive strength and flexural strength compared to the reference samples.

2. LITERATURE REVIEW

Salvetat, Bonard, Thomson, Kulik, Forr´o, Benoit, Zuppiroli (1999) investigated the Theory and experiments show that the Young's modulus of CNTs is at least as high as graphite and can be even higher for small SWNTs. Our experiments show that Young's moduli for MWNTs are dependent upon the degree of order within the tube walls. Fig. 3 shows a schematic representation of these findings, where the Young's modulus decreases as the disorder increases. Disorder is difficult to quantify from any experimental method and therefore is an arbitrary scale in Fig. 3. The arc-grown MWNTs show a modulus close to that of graphite (approximately 1 TPa), but this drops by about an order of magnitude for MWNTs grown by catalytic methods. In addition, the dispersion of the measured values of E tends to increase as disorder within the tube walls increases. Correlation of strength with disorder will be essential for the development of reproducible CNT composites which take full advantage of the outstanding mechanical properties of CNTs. The theoretically predicted properties of CNTs – high strength, extraordinary flexibility and resilience – are now being observed by experimentalists. Moreover, good load transfer between polymer matrices and the outer surface of CNTs suggest that these exceptional mechanical properties will be reflected in composites.

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.

A.Cwirzen, K.Habermehl Cwirzen (2008) found that the increase in the compressive strength of nearly 38% to 50% even with only a small addition of the MWCNTs, namely 0.045–0.15% of the cement weight. Highest increase in the compressive strength was nearly 50% in cement paste incorporating only 0.045% of the the polyacrylic acid polymer-treated MWCNTs.

Simone Musso a, Jean-Marc Tulliani, Giuseppe Ferro, Alberto Tagliaferro (2009) stated that the mechanical strength by a factor of 2.5 with respect to the plain cement in the presence of pristine CNTs produce an enhancement of approximately 34% and Annealed CNTs-cement composite showed a negligible improvement of approximately 9%.The average compression resistance of the two half of the prism made with f-CNTs was even six times lower with respect to the concrete with no CNTs: 104 ± 20 kN and 15.53 ± 3.04 kN, respectively.

Abu, Shadi (2010) investigated the effect of different concentrations of long Multi-Walled Carbon Nanotubes (MWCNTs) and short MWCNTs on the modulus of elasticity for the specimens showed slight increase of 15 to 20%.

Sanjeev Kumar, Prabir Kolay, Sunil Malla ; and Sanjay Mishra (2012) investigated the from the various experimental investigations conducted on cement CNT composites, the following conclusions are drawn:

1. Increase in compressive and splitting-tensile strength was noticed in cement-CNT composites having CNT content of 0.5% by weight of cement. The increases in the previously mentioned strengths with respect to control mix were 15% and 36%, respectively, at 28 days of curing. Cement-CNT composites with 0.75% CNT showed almost the same compressive and splitting-tensile strengths as that of the control mix.

2. The control mix and all cement-CNT composites showed considerable strength (mechanical) gain from 7 days of curing to 28 days of curing. The rate of change of compressive and splitting-tensile of all cement-CNT composites with respect to curing age was seen to be very similar to that of the control mix. This indicates that the strength gain of composites is primarily because of cement hydration and the fact that CNTs are not reacting with cement compounds.

3. A small increase in compressive and splitting-tensile strengths was observed as the sonication time increased from 30 min to 4 h for specimens tested after 90 days of curing. However, specimens tested at other curing ages did not show consistent results. Based on the results obtained, it was concluded that increased sonication period did not cause a significant change in the mechanical strengths of the composites.

4. The SEM data showed non-uniform dispersion of CNTs in the cement matrix, and this appears to be the reason for the lower strengths of the composites with higher CNT content. However, the embedding of CNT in the cement matrix bridging micro cracks was observed. Based on the results obtained, it was concluded that the way CNTs were sonicated was not good enough to disperse them in an effective manner.

5. Detailed morphology of CNT and cement compound strand was studied using TEM. Although it is difficult to conclude if there existed any chemical bonding between cement compounds and CNT, it was verified from this test that there was a physical bonding between cement matrix and CNT. The diameter of the cement compound strand was almost the same as that of CNT.

Abu et al. (2013) discovered that in addition, the long 0.1% MWCNT had also increased flexural strength by 65%.

Madhavi (2013) investigated to based on the above experimental investigation, the following conclusions were be drawn:

1. The slump value remains constant for various proportions of MWCNT in concrete mix.

2. From the results, it is understood that increasing the proportions of functionalized MWCNT into concrete increases the compressive strength. The compressive strength of the concrete with a proportion of 0.045% of functionalized MWCNT increases by 26.69%.

3. By increasing the percentage of functionalized MWCNT to the concrete, the water absorption is reduced to a greater extent which helps in improving the concrete to be more durable and water resistant. The water absorption

for 0.015% functionalized MWCNT into concrete decreases by 10.22% and for 0.045 % addition, the water absorption decreased creased by 17.76%.

4. The split tensile strength increases by with increase in MWCNT. The split tensile strength increased by 66.3% for 0.045% of MWCNT.

Abinayaa, Chetha, Chathuska, Praneeth (2014) investigated the from the results, it is 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 increases with the increase in MWCNT (Table 3). In fact, the split tensile strength increased by 66.3% for 0.045% of MWCNT. With the increase in MWCNT, the rate of increase of tensile strength is greater than that of the rate of increase of the compressive strength.

Abinayaa , Chetha , Chathuska, Praneeth , Vimantha , Wijesundara (2014) investigated the Based on the above experimental investigations, the following conclusions can be drawn: From the results, it is understood that increasing the proportions of functionalized MWCNT into concrete increases the compressive strength (Table 2, 3). 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 increases with the increase in MWCNT (Table 3). In fact, the split tensile strength increased by 66.3% for 0.045% of MWCNT. With the increase in MWCNT, the rate of increase of tensile strength is greater than that of the rate of increase of the compressive strength.

Anand Hunashyal , Nagaraj Banapurmath , Akshay Jain , Sayed Quadri (2014) investigated the the addition of MWCNTs-0.75%,Nano silica- 0.5%,and both along with cement composites shows increase of compressive strength as 33.75N/mm^2 36.75 N/mm^2 38 N/mm^2 respectively for M 25 grade mix.

Rafat Siddique, Ankur Mehta (2014) stated that the compressive strength of plain concrete and MWCNTs reinforced mortar increased as 150% 170% 120% respectively at 7,14 and 28 days respectively.

Metaxa et al. (2014) studied the flexural strength of Multi-Walled Carbon Nanotubes (MWCNTs) cement composites with two different suspension techniques showed the increase of flexural strength upto 160 to 240%.

Yu Hu, Danni Luo, Penghui Li, Qingbin Li, Guoqiang (2014) gave that the fracture properties improvement on the cementitious properties.

Salomaa, Amrinsyah Nasutionb, Iswandi Imranb, Mikrajuddin Abdullahb (2015) Investigated the Based on the research conducted on the concrete nanomaterials can be summarized as follows:

1. Nanosilica is capable of improving the performance of concrete.

2. Based on the test results of concrete compressive strength at 28 days, a maximum compressive strength value is 129.48 MPa.

3. The improvement of 10% nano silica replacement in the resistance to sulfate attack is better than that of 0% nano silica.

Inkyu Rhee (2016) investigated the amount of material 0-1.5% (By wt of cement) Size of Specimen: 10cm x 20cm (cylinder) 4x4x16cm (Mortar flexural bending and shrinkage with prismatic specimen Methodology: Dispersion method with sodium naphthalene and sulphonate formaldehyde solution 0.15 to 1.5% dispersive solution with CNT Ultrasonication treatment to each diluted solution for 20min. Mechanical properties: Compressive strength is increased by 19%, Flexural strength is increased by 25%, W/C ratio is 0.45.It has concluded as comparison of mechanical properties with dispersion and without dispersion.

Josef Foldyna,Vladimír Foldyna (2016) found that the 0.2% by weight of MWCNT were added to cement CNT are added to the water by sonication process Compressive strength increases upto 22% when CNT were dispersed in DI water with sonication at 35 days curing.

Victor Vaganova , Maxim Popovb , Aleksandrs Korjakinsc , Genadijs Šahmenko (2017) investigated the In order to evaluate strength and durability of foam concrete with foamed glass grains, the samples were prepared from high density and low density foam concrete without foam glass grains and with grains. Adding light weight foamed glass grains decrease the strength in the case oh high strength foam concrete and don't effect in the case of low strength foam concrete. Advantaged of foamed glass adding are decreasing of density (especially in the case of high density foam concrete) and considerable decreasing of surface water absorption. Frost resistance of medium density FC 30 cycles, but 100 cycles for high density foam concrete, that is comparable with normal concrete. It is proved that adding foamed glass did not reduced frost resistance of foam concrete. Considering the interaction mechanism between CNT and foam concrete it may suppose, that application CNT can improve foam concrete durability. CNT have a significant effect on the hydration kinetics, structure and phase composition of the concrete. Due to this graphene surface of CNT can interact with the hydrate ions generated during the dissolution of the clinker phases. Particular attention is paid to the interaction of the Ca2+ and CNT, because the concrete strength development and structure of cement stone are determined mainly by these ions. The interaction between calcium ions and aromatic hydrogen usually takes place according to polarization mechanism. Water leads to a reduction of this interaction due to the high value of the dielectric constant. On the other hand, the electron structure of carbon nanotubes is closer to graphene than hydrocarbon, which suggests the difference in the mechanism of their interaction with calcium ions.

3. MATERIAL PROPERTIES

Carbon materials are found in variety forms such as graphite, diamond, carbon fibers, fullerenes and carbon nanotubes. The reason why carbon assumes many structural forms is that a carbon atom can form several distinct types of valence bonds, where the chemical bonds refer to the hybridization of orbitats by physicists. This chapter introduces the history of carbon materials and describe the atomic nature of carbon.

Carbon nanotubes are a form of carbon having a cylindrical shape, the name coming from their nanometre diameter. They can be several millimeters in length and can have one "layer" or wall (single walled nanotube) or more than one wall (multi walled nanotube) . Nanotubes are members of the structural family and exhibit extraordinary strength and unique electrical properties, being efficient thermal conductors. For example, they have five times the Young's modulus and eight times (theoretically 100 times) the strength of steel, whilst being 1/6th the density. Expected benefits of carbon nanotubes are: mechanical durability and crack prevention in concrete enhanced mechanical and thermal properties in ceramics and real-time structural health monitoring capacity. The structure of carbon nanotubes is as shown in the Fig.1

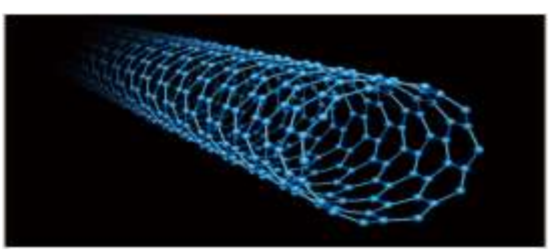

Fig-1: CARBON NANOTUBE (www.googleimages.com)

Carbon Nanotubes are the potential candidates for the use as nano-reinforcements in cement-based materials. They exhibit extraordinary strength with modulii of elasticity on the order of TPa and tensile strength in the range of GPa and they have unique electronic and chemical properties.

They are of two types:

1. Single-wall carbon nanotubes (SWCNTs)
2. Multi-wall carbon nanotubes (MWCNTs)

4. PHYSICAL PROPERTIES OF CARBON NANOTUBE

When **Sumio Iijima** discovered carbon nanotubes in **1991**, they were just thin and long cylinders of carbon and it was unknown at the time what the implications of this discovery would be. The physical properties of carbon nanotubes, including their size, shape and ability to be manipulated, yet stay strong, have made them a unique find amongst other macromolecules. Essentially, a carbon nanotube is akin to a sheet of graphite that has been rolled up into a cylindrical shape. This sheet is comprised of a hexagonal latticework, making the physical properties of carbon nanotubes that much more fascinating and strange to both scientists and physicists. It is simply the construction of the physical properties of carbon nanotubes that makes them so unique and such a hotly debated topic. Carbon nanotubes have been known to change depending on the situation they are placed into. They are capable of adapting and changing to meet the needs of electronic, thermal and structural properties. Additionally, the physical properties carbon nanotubes change based on the type of nanotube being used as the type being defined by the length and diameter of the nanotube as well as the twist (also known as the chirality).

The type of carbon nanotube as defined has a great deal to do with determining the electronic properties of a carbon nanotube. The chirality itself determines whether the carbon nanotube is a metal, semimetal or semiconductor and its implications for science and electronics will be determined by its makeup. Carbon nanotubes have been known for some time to be excellent conductors of electricity. This conductivity allows for the use of bundled carbon nanotubes as microscopic tweezers.

The physical properties of carbon nanotubes also segue into an area where many other macromolecules have not been found to venture. Carbon nanotubes have been described as being able to exist as a Single Walled Nanotube (SWNT) or as a Multiple Walled Nanotube (MWNT). In the Multiple Walled Nanotube, one cylinder (or rolled sheet of carbon nanotubes) is inside another cylinder, like nesting dolls. Each of these types of carbon nanotubes have their own physical properties in addition to the standard physical property sets for carbon nanotubes and due to the complex nature of Multiple Walled Nanotubes, they often have many defects and are unusable for several of their major physical properties.

Some of the major properties of carbon nanotubes are the optical properties. In science, if a macromolecule has optical properties that means that it is has properties relating to the principles of photoluminescence, light absorption and that it is able to register light on the Raman spectroscopy. The abilities associated with the optical physical properties of carbon nanotubes are as yet unclear, but it is possible that the carbon nanotube could have implications in the development of optics, photonics, LEDs (or Light Emitting Diodes) and even photo-detectors, among other optical devices.

But the properties of carbon nanotubes are not limited to optical properties. Thermal properties of carbon nanotubes have great implications for science as well. In some experiments, carbon nanotubes have been added to epoxy resin in a successful attempt to double the thermal conductivity in the resin. With this being achieved at only a 1% loading, the experiment proved that carbon nanotubes can be used successfully for thermal management applications when used as part of a composite material.

Additionally, nanotubes are said to have elastic properties as well. While these elastic properties are hotly debated in many scientific circles, it is agreed that carbon nanotubes are one of the most flexible macromolecules in existence today. While there are no defined uses for the extreme flexibility of carbon nanotubes, this elasticity could have implications for the development of a wide variety of products, including bullet proof vests though the strength of carbon nanotubes alone could merit this and other safety devices.

Among the many physical properties of carbon nanotubes is the fact that this macromolecule is anisotropic which means that it is directionally dependent. On the other hand, isotropic molecules are not directionally dependent and do the same thing no matter which direction they are going or being pulled. This property is precisely how carbon nanotubes are able to fulfill the needs of many different physical properties without being deficient in any one area. The anisotropic properties of carbon nanotubes could have implications for a wide variety of fields, including but not limited to chemistry, computer graphics, wood and woodworking, real world imagery, geophysics, physics, medical acoustics, material science, engineering, microfabrication and a host of other fields of discovery and invention that are seeking the perfect solution to every problems.

5. MECHANICAL PROPERTIES OF CARBON NANOTUBE

Carbon nanotubes are the strongest and stiffest materials yet discovered in terms of tensile strength and elastic modulus respectively. This strength results from the covalent sp^2 bonds formed between the individual carbon atoms which are stronger than 3D diamond bonds.

5.1 Young's Modulus:

Lourie and Wagner experiment using bar model and reports Young's modulus of 2.8-3.6TPa, for SWCNT and 1.7-2.4 TPa for MWCNT.

Yu et al. obtained ranges from 320 to 1470 GPa(mean: 1002 GPa) for SWCNT and from 270 to 950 GPa for MWCNT using direct tensile loading tests. The simply-supported beam model was used by **salvetat** et al. to model the deflections of individual MWCNTs; a Young's modulus of~1 TPa for MWCNTs.

Wong et al using cantilevered beam model obtained modulus of 1.28± 0.59 TPa for MWCNTs.

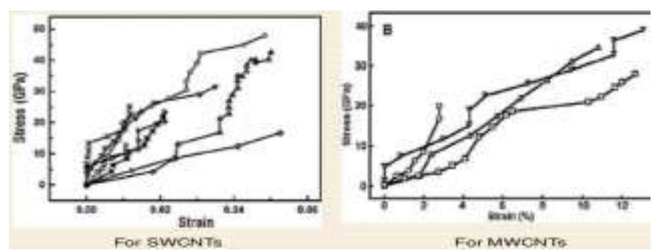

Fig 2: Stress versus Strain curves for CNTs

5.2 Strength of CNTs

Tensile load testing was performed by Yu et al. On SWCNT bundles and tensile strength values ranging from 13 to 52 GPa and maximum tensile strain obtained was 5.3% wera reported.Yu et al. Have also conducted tensile testing of MWCNTs.It was found that only the outermost layer breaks during the loading process. The tensile strength corresponding to this layer of CNT ranges fron 11 to 63GPa.

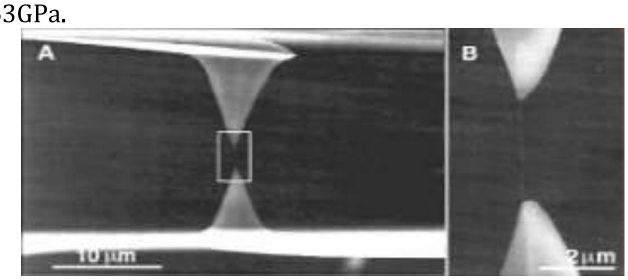

Fig 3: Strength of CNT

Table 1 Comparison of Mechanical properties

Material	Young's modulus (T-150Pa)	Tensile strength (GPa)	Elongation of break(%)
SWCNTs	~1	**13-53**	**16**
Armchair SWNT	0.94	**126.2**	**23.1**
Zigzag SWCNGT	**0.92**	**NA**	**NA**
MWNT	**0.2-0.9**	**NA**	**NA**
Stainless steel	**0.18-0.26**	**0.38-1.55**	**15-50**
Kevlar	**0.06-0.18**	**3.6-3.8**	~**2**

6. ELECTRICAL AND ELECTRONICS PROPERTIES

6.1 Behaviours According to Structure

- Chiral Vector $\mathbf{ch=n_1a_1 + n_2a_2}$
- If $\mathbf{n_1=n_2}$ **teh nanotube is metallic**
- If (n_1-n_2) is a multiple of 3, then the nanotube is semiconducting wuth avery small bond gap, otherwise the nanotube is a mderate semiconductor

6.2 Thermal properties

The thermal properties of carbon nanotubes are directly related to their unique structure and small size

- Specific Heat
- Thermal conductivity

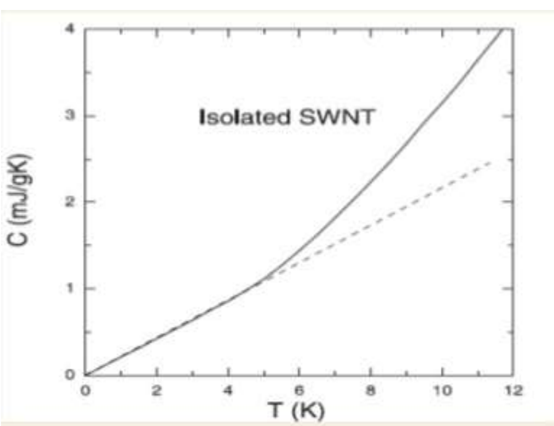

Fig – 4 Comparison between Temperature and Energy

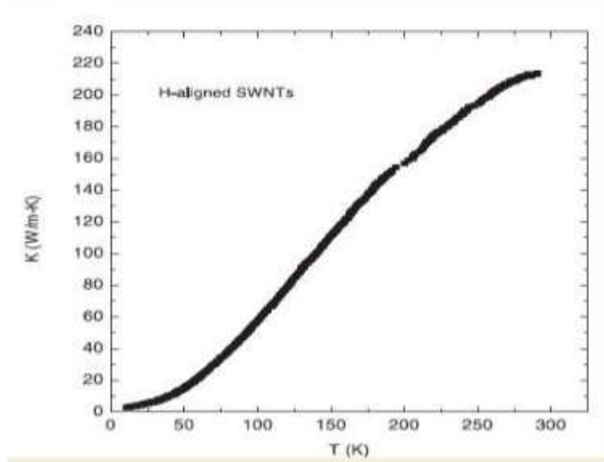

Fig – 5 Comparison between Temperature and Electrical Conductivity

7. APPLICATION OF CARBON NANOTUBE

Nanotechnology has the potential to be a key to the brand new world in the field of construction and building materials. Until today concrete has primarily been seen as a structural material but nanotechnology especially carbon nanotubes helps to make it as a multi-purpose "smart material". Following are some of the applications of carbon nanotubes:

➢ CNTs in concrete increase its tensile strength. The highest tensile strength of an individual multi-walled carbon nanotube has been tested to be is 63Gpa.

➢ They help in controlling the crack propagation.

➢ The addition of CNT to concrete can significantly enhance some mechanical as well as physical properties of the material. Use of carbon nanotubes increases the strength and durability of cementitious composites as well as for pollution reduction. When researchers think of nanomaterials reinforcements for concrete, carbon nanotubes come as the first¬ option. Also the research done so far has shown that single and multi-walled nanotubes can produce materials with toughness unmatched in the man-made and natural worlds. The strength and flexibility of carbon nanotubes makes them of potential use in controlling other nanoscale¬ structures, which suggests they will have an important role in nanotechnology engineering. It has been proved that there is good interaction between CNTs and cement phases indicating the potential¬ for crack bridging and enhanced stress transfer.

➢ When researchers think of nanomaterials reinforcements for concrete, carbon nanotubes come as the first option. Also the research done so far has shown that single and multi-walled nanotubes can produce materials with toughness unmatched in the man-made and natural worlds.

➢ The strength and flexibility of carbon nanotubes makes them of potential use in controlling other nanoscale structures, which suggests they will have an important role in nanotechnology engineering.

➢ It has been proved that there is good interaction between CNTs and cement phases indicating the potential for crack bridging and enhanced stress transfer.

8. CONCLUSION

- Concrete is a properly proportioned mixture of water, cement, fine and coarse aggregates that can be used as a construction material to build various structures from nuclear radiation shield to very basic structures like houses as it can be poured into any shape unlike most other materials. Out of the above ingredients, cement plays a major role chemically as well as physically to show the properties of the concrete.

- Cement is gray color fine powder, chemically formed by raw materials such as calcium oxide (CaO), silica (SiO_2), alumina (Al_2O_3), and iron oxide (Fe_2O_3) heated to a temperature around 1200 – 1400 o C in kiln. During the process of mixing the ingredients inside the rotary kiln, the four major mineral constituents of cement are born. These are the main compounds that participate in strength gaining of concrete.

- These four components participate in gaining strength at different stages. Tri-calcium silicate (C_3S) hydrates and hardens rapidly and it is highly responsible for initial set and the early strength gained whereas tricalcium aluminates (C_3A), hydrates and harden the quickest. C_3A also liberates a large amount of heat immediately and contributes somewhat to the early strength. The quick hardening nature of C_3A is the reason to add gypsum to cement mixture in production. Di-calcium silicate (C_2S) hydrates and hardens slowly and is very much responsible for long term strength increase i.e. beyond one weeks' time. Last but not least contributing the least on strength is tetra-calcium alumino-ferrite (C_4AF), still hydrates rapidly.

- 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. Therefore our objective of this literature survey to summarize the past experimental data on improving the properties of concrete using carbon nanotubes. Therefore, the effects after adding nanotubes into the mixture is concluded by the results obtained upon testing different grades of concrete using different methods of diffusing and tested for compression, tension and bending strengths.

- The addition of small amounts (1 % wt) of cnt can improve the mechanical properties of samples consisting of the main portland cement phase and Water.

- Oxidized multi-Walled Nano tubes (MWCNT's) show the best improvements both in compressive strength(+25 N/mm^2) and flexural strength (+8N/mm^2) compared to the sample without reinforcement.

- A number of investigation has been carried out developing smart concrete using carbons fibers.

REFERENCES

1. Abinayaa , Chetha , Chathuska , Praneeth, Vimantha , Wijesundara "Improving the Properties of Concrete using Carbon Nanotubes" in SAITM Research Symposium on Engineering Advancements 2014 pp. 201-204.

2. Anand Hunashyal, Nagaraj Banapurmath, Akshay Jain, Sayed Quadri and Ashok Shettar "Experimental Investigation on the Effect of Multiwalled Carbon Nanotubes and Nano-SiO_2 Addition on Mechanical Properties of Hardened Cement Paste" in Advances in Materials Volume 3, Issue 5, October 2014, pp. 45-51.

3. Cwirzen. A, Habermehl Cwirzen. K and Penttala. V "Surface decoration of carbon nanotubes and mechanical properties of cement/carbon Nanotube composites" in Advances in Cement Research, 2008, 20, No. 2, April, pp.65–73.

4. Glass Victor Vaganova , Maxim Popovb , Aleksandrs Korjakinsc , Genadijs Šahmenkoc "Effect of CNT on Microstructure and Minearological Composition of Lightweight Concrete with Granulated Foam" in Procedia Engineering 172 (2017) pp. 1204 – 1211.

5. Inkyu Rhee, Young-Sook Roh "Properties of normal-strength concrete and mortar with multi-walled carbon nanotubes" in Magazine of Concrete Research 65(16) August 2013 pp 951-961.

6. Inkyu Rhee, Young-Sook Roh "Properties of normal-strength concrete and mortar with multi-walled carbon nanotubes" in Magazine of Concrete Research Volume 65 Issue 16 pp. 951-961.

7. Jyoti Bharj, Sarabjit Singh, Subhash Chander, Rabinder Singh "Role of Dispersion of Multiwalled Carbon Nanotubes on Compressive Strength of Cement Paste " in International Science Index, Materials and Metallurgical Engineering Vol:8, No:2, 2014 pp. 340-343.

8. Madhavi Ch. T., Pavithra.P, Sushmita Baban Singh Vamsi Raj. S.B, Surajit Paul "Effect of Multiwalled Carbon Nanotubes On Mechanical Properties of Concrete" in IJSR - INTERNATIONAL JOURNAL OF SCIENTIFIC RESEARCH Volume 2(6) June 2013, pp. 166-168.

9. Nochaiya T, Chaipanich A. "Behavior of multi-walled carbon nanotubes on the porosity and microstructure of cement-based materials" in Applied Surface Science 2011; 257(6) pp. 1941-1945.

10. Salomaa, Amrinsyah Nasutionb , Iswandi Imranb , Mikrajuddin "Improvement of concrete durability by nanomaterials" in the proceedings of The 5th International Conference of Euro Asia Civil Engineering Forum (EACEF-5) pp. 608 – 612.

11. Sanjeev Kumar, Prabir Kolay, Sunil Malla; and Sanjay Mishra "Effect of Multiwalled Carbon Nanotubes on Mechanical Strength of Cement Paste" in Journal of Materials in Civil Engineering Volume 24 Issue 1 - January 2012 pp 84-91.

12. Simone Musso, Jean-Marc Tulliani , Giuseppe Ferro c , Alberto Tagliaferro Influence of carbon nanotubes structure on the mechanical behavior of cement composites in Composites Science and Technology 69 (2009) pp. 1985–1990.

13. Singh N.B.,Saxena S.K Mukesh Kumar "Effect of nanomaterials on the properties of geopolymer mortars and concrete" in Procedia Engineering Volume 149, 2016, pp. 94-99.