Experimental Study on Mechanical Properties of CNT Reinforced Concrete

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ABSTRACT

Concrete is a well proportionate mixture of cement, fine aggregate, coarse aggregate and water. Concrete is strong in compression but week in tension. To avoid this disadvantage and to increase the strength of concrete we have to add some percentage fibers in concrete. Many researchers have work to improve tensile strength of concrete by adding different fibers (steel fibber, glass fibers, carbon fibers, natural fibers etc.) in different percentage in concrete. Researcher is work for new materials for improving the tensile strength.

Now the work is going towards the nanotechnology for concrete. In this paper the previous work of researchers on nanotechnology is highlighted and mostly on carbon nanotubes. This study work on the methods of manufacturing the carbon nanotubes such as electric arc-discharge, laser ablation method and chemical vapour deposition. In this Project an attempt has been made to use carbon nanotubes in concrete with different percentage (0.015, 0.020, 0.030, and 0.040%) of weight of cement. This addition is done for studying the effect of addition of carbon nanotubes on various mechanical properties of concrete, like compressive strength, flexural strength, split tensile strength.

Keyword: *Strength, Stiffness, Splitting tensile strength. Flexural strength Carbon nanotube · Cement · Multiwall nanotube · Dispersion · Mix proportion***.**

1. INTRODUCTION

Carbon nanotubes are recognized at the present time as being materials having great advantages because of their mechanical properties, their very high form factor (length/diameter ratio) and their electrical property. Carbon nanotubes are hexagonally shaped arrangement of carbon atoms that have been rolled into tubes. They are made up from graphite sheets that are wound up and terminated by hemispheres consisting of pentagons and hexagons with a structure similar to fullerenes. Nanotubes are known to be composed of either a single sheet referred to as single-walled nanotubes (SWNT) or of several concentric sheets called multi-walled nanotubes (MWNT). Carbon nanotubes (CNT) are a very efficient reinforcing agent due to its extremely high aspect ratio and ultra-high strength. So, there is high potential to utilize CNT in producing new cement based composite materials. Carbon nanotubes have drawn tremendous interest from fields ranging from condensed matter physics to chemistry and from both academia, and industry, because of the unique properties enabled by their Nano scale structure. [1]

Nano materials exhibit distinctive chemical and physical properties that can result in the improvement of material performance. Carbon nanotubes (CNTs) are allotropes of carbon with a cylindrical nanostructure. These cylindrical carbon molecules have unusual properties, which are valuable for nanotechnology, electronics, optics and other fields of materials science and technology. In particular, owing to their extraordinary thermal conductivity and mechanical and electrical properties, carbon nanotubes find applications as additives to various structural materials. For instance, nanotubes form a tiny portion of the material(s) in some (primarily carbon fiber) baseball bats, golf clubs, or car parts. Experimental Study on Mechanical Properties of CNT Reinforced Concrete Nanotubes are members of the fullerene structural family. Their name is derived from their long,

hollow structure with the walls formed by one-atom-thick sheets of carbon, called graphene. The basic structure of a carbon Nanotube is a hollow cylindrical tube of graphitic carbon capped by fullerene hemispheres with Nanometer size diameters and macroscopic size lengths. The Nanotubes may consist of one to hundreds of concentric graphitic shells of carbons. [1]

2. EXPERIMENTAL PROGRAM

The experimental program was conducted in two phases. MWNTs were used as reinforcing agent. The first phase of the study was conducted to explore the effect of MWNT dosage rate, MWNT size and different mix proportions on compressive strength of MWNT cement composites. For the experimental program M_{30} grade of concrete Mix design should be done.Four different proportion of commercially available MWNT were used as reinforcement. Different mixing methods using ultrasonication for uniform dispersion of MWNT within cement matrix were examined to suggest a suitable mixing technique [9]. Based on the first-phase test results, the better-performing mix proportion and a particular size of MWNT were chosen for further investigation in the second phase [4-5]. In this article, discussions on the study Mechanical properties in brief with particular emphasis on various factors that have considerable influence on strength of MWNT-reinforced cement composites. [6]

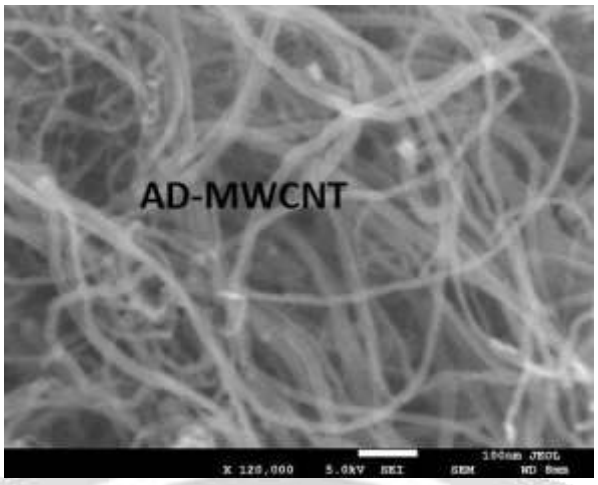
3. MATERIAL USED

Ordinary type II Pozzolana Portland cement (P.P.C) was utilized in this study. Special graded sand according to ASTM c109 (2008) was utilized. Commercially available MWCNTs were obtained from a (supplier "from "Ad-nano technologies private limited" Machenahalli industrial area shimoga-577222, Karnataka, India.) Manufacturer in powder form having outside diameter (OD) of 10-15 nm. Mwcnt is the ultra pure multi-wall carbon nanotubes produced by the catalytic carbon vapour deposition (CCVD) process such longer MWCNT is expensive than that of shorter length. Various properties of the MWCNT are provided in table 1. & Fig. 1 shows the Scanning electron microscopy (SEM) image of the MWCNT. Polycarboxylate based super-plasticizer ad. Cast 575 was used as plasticizer in the experiments to improve the workability of the mix and also as a surfactant to disperse MWCNTs. [6]

Table 1.Surface Treated MWCNT Properties

Parameter	Value
Type	Multiwall Carbon Nanotubes
Colour	Black
Purity	>99%
Avg. Dia.	10-15 μm
Avg. length	~5 μm
Amorphous carbon	<1%
Specific Surface Area (SSA)	~400m^2/g

Fig No.1 MWCNT (Scanning Electron Microscopy Image)



4.MIXING PROCESS

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 MWNT was procured in powder form. Uniform distribution of nanotubes in cement composite is essential to ensure reinforcing behavior of fibers. However, mixing of MWNT is difficult using conventional process since large surface area of nanotubes result in extremely high van der Waals forces and causes agglomeration. 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 Sonicator** (LABMAN Scientific Instruments limited) of **NCFRR** Lab under **Chemistry Department of Savitribai Phule Pune University, Pune.** 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.

5. EXPERIMENTAL PROGRAM

5.1 Testing procedures

The compressive strength at ages 28 days was tested at a loading rate of 0.5 MPa/s. Three-point bending Tests were carried out to quantify the influence of the MWCNTs on nanocomposites' flexural strength, and the Distance between the two supports was 120 mm. The specimens were tested using an Instron Model 8802 universal material testing machine (with 0.1 mm/min loading speed) at 28 days. Workability or consistency of concrete mix is determined by Slump cone test.

6 RESULTS AND DISSCUSSIONS

- **Slump Cone Test**

The effect of Carbon Nanotubes on workability of concrete for various mixtures is given in Table 4.1

Table 4.1- Slump cone test results

Sr.no	Samples	Slump(mm)
1.	PC	95
2.	CNT 0.015%	96
3.	CNT 0.020%	96
4.	CNT 0.030%	98
5.	CNT 0.040%	100

- **Mechanical properties**

The mixture proportions and compressive strength testing results with the consistent water– cement ratio of 0.35, the compressive strength increased with increasing MWCNT content. At 0.015 wt%,0.020 wt%,0.030 wt% and 0.040 wt% MWCNT content, the compressive strength was enhanced (relative to the control) by 5%,13%, and 21% and 15% at 28 days, respectively. Clearly, the early age strength of cement paste was greatly improved by MWCNT addition. MWCNTs enhanced the flexural and compressive strengths simultaneously. The results of the three-point bending tests showed that the peak value of flexural stress was significantly influenced by the amount of MWCNT added. It was found that flexural strength increased with increasing MWCNT content. Relative to the control, flexural strength increased by 8%,16%,35%and 33% with 0.015 wt% and 0.020 wt%, 0.030wt%, 0.040wt% MWCNT content, respectively.

5 CONCLUSION

After studying the several test results of different specimens ranging in Carbon Nanotubes content from 0.015% to 0.040% by weight of cement, the following conclusions are deduced,

1. MWCNT reinforced concrete samples performed better in compression test, Spliting and flexure.
2. Increasing the proportions of functionalized MWCNT into concrete increases the compressive strength. The compressive strength of the concrete with a proportion of 0.030% of functionalized MWCNT increases by 21% and for 0.040% increase by 15%.
3. The split tensile strength increases with the increase in MWCNT . In fact, the split tensile strength increased by 35% for 0.030% of MWCNT and for 0.040% Carbon nanotubes is 33%
4. 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.
5. From the above results it is that the 0.030% addition of CNTs gives highest result for all three strength test.
6. Ultimately Carbon Nanotube based concrete gives more strength than conventional concrete.

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