Carbon Nanotubes as Cementious Material, Effects and Properties in Cement Composites – A Review

R. Madhusudhana , K. L. Sushma , L. Krishnamurthy, R. Gopalkrishne Urs

Abstract— **Cement is commonly used in all the construction industries. This wide usage of cement has become more which may cause some important environmental impact. In order to avoid this, Carbon Nanotubes (CNT's) are used as cementious material as they exhibit remarkable mechanical properties like tensile strength, compression strength. These kinds of Nano materials also enable structural and energy conversation. In this paper, we review the effects of incorporation of CNT's used as cementious material and the methods by which CNT's are dispersed into cement**.

***Index Terms*— Cement, Carbon Nanotubes (CNT's), Dispersion, MWCNT'S**

I. INTRODUCTION

Ordinary Portland cement is used as a binding material in almost all the construction industries. Usually these cement particles hardens and adheres to foreign materials used in construction. Generally cements used will have four different major phases i.e., Alite, Belite, Celite, Brownmilirite. Among these, Alite and Belite are said to be responsible for the variation of strength in the cement [1]. Basically the manufacturing of cement is done by heating the mixtures of lime stone, clay and sand at a high temperature at 1450° C in the rotating kilin, then cooled and ultimately cement product will be obtained. CNT's was discovered by Iijima in 1991 which basically it can be categorized into two forms i.e. Single - Walled Carbon Nanotubes (SWCNT's) and Multi - Walled Carbon Nanotubes (MWCNT's). Single - Walled Carbon Nanotubes means comprises of single layer of Graphene (Fig. 1) but in terms of Multi-Walled Carbon Nanotubes, it exhibits many layers in concentric manner and their diameter tend to increase from one another (Fig. 2).

Fig.1 : Single wall carbon nanotube [2]

Fig. 2 : Multi-Walled Carbon Nanotube [2]

The properties of SWCNT's are more efficient when compared to MWCNT's but still MWCNT's are preferred in the construction industries because of the ease and convenient production of MWCNT's as compared to SWCNT's, and the diameter of each layer of SWCNT's carbon nanotubes will be around 0.4nm [3].

II. PROPERTIES OF CARBON NANOTUBES

CNT's basically being nanostructured in nature provides excellent electrical, mechanical and thermal properties and hence strength between the bonds and carbon atoms tend to be strong. One major advantage of CNT's is that they can be chemically modified and functionalized as per the desired output. SWCNT's will be of one dimensional structure characteristics and it will be having some kind of different and special electrical properties, these CNT's will be of low resistance in electrical properties. Resistance can be seen when electrons hits defects by which it can move in the crystal structure [3].

These CNT's show excellent mechanical properties since the bonding between each atom comprises of covalent bond sp2 hybridization and these are excellent in the direction of essentially perpendicular to the plane of a structure. Young's modulus and tensile strength will be in the range of 270 – 950 GPa and 11-63GPa respectively [4]. Graphite is of sp2 hybridization it shows the highest thermal conductivity so from this we can say that ultimately CNT's thermal conductivity will also be highest [5]. By using the phonons the specific heat and thermal conduction can be known [3].

III. SYNTHESIS TECHNIQUES

A. Synthesis of CNT'S

Materials required is CNT's here we are going use MWCNT's due to requirements of large production for the

industries. To obtain the carbon nanotubes to our requirement such as size and shape we can employee many methods basically the growth of CNT's requires the temperature of about 700°C - 900°C, this is because to undergo the catalytic process [6]. For the large production of MWCNT's thermal CVD process will be used since it is economical when compared to other method [6].

B. Dispersion of CNT'S into cement

CNT's having large surface area will be having the weak van der waal forces which may lead to get agglomerate each other which will lead to problem in proper dispersion into the cement[7]. In this case a mechanical approach i.e., ultrasonication can be done which helps in separating the nanotubes[7].

Li et. al. [8] CNT's was treated with carboxylic acid and added to the sulfuric acid and nitric acid, the solution was under the sonication process for 3hrs which results in oxygen containing functional groups in the room temperature after that mixtures was diluted with distilled water after 24 hrs diluted portion will be removed, this process was continued until no residual acid present.

Further, it was characterized by SEM (Fig .3) and FT-IR spectra, UV-Vis which shows dispersion of CNT's was good and formation of C-S-H i.e., bond between functional group and cement hydration was formed (Fig. 4). In the figure, we can see the C–S–H growth on CNT's network during hydration process. From (a) to (d), the hydration time are 60 min, 135 min,180 min and 240 min, respectively [9].

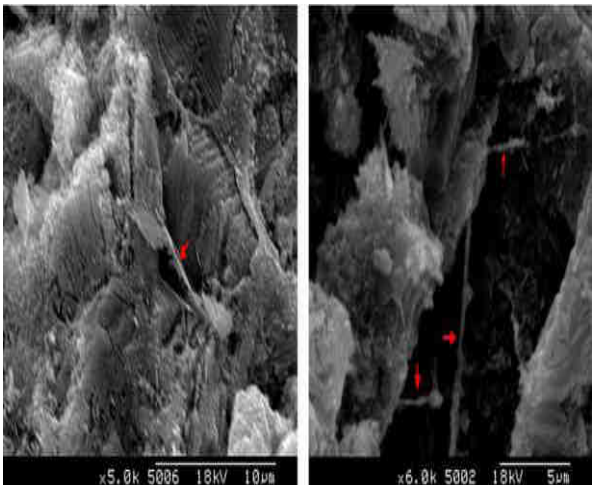

Fig. 3. SEM image of carbon fibers cement matrix composites [8]

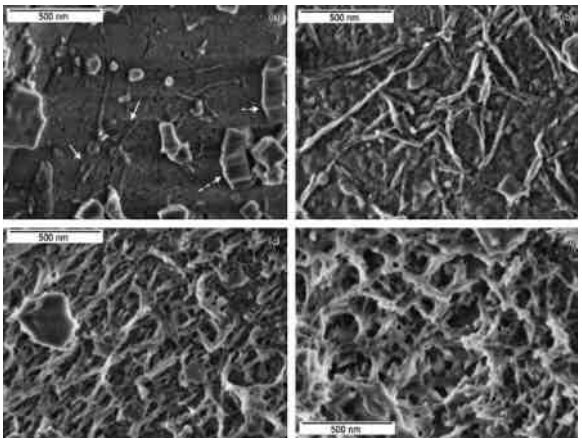

Fig. 4. C–S–H growth on CNT network during hydration [9]

IV. ESTIMATING SCATTERING AND UPRIGHTNESS OF CNT'S AS CEMENTITIOUS COMPOSITE

Different proportion of cement and CNT's will be taken after the age of 28days there strength like flexural strength and compression strength will be studied. After their strength testing is done sample will be collected in order to check its pore size and porosity [8]. In order to know the microstructure characterization techniques like SEM, UV-Vis absorbance and FT-IR spectra, can be conducted. The most straight forward procedure to show the scattering procedure in subjective way is visual inspection; the further developed scattering process, the darker the shade of the suspension [10]. At the point when the agglomeration of CNT's takes places, the force of ingestion band can be straight forwardly connected with the level of scattering, permitting the assurance of the ideal scattering boundaries for each cases [11]. Fig. 5 shows the UV-Vis retention spectra obtained for a suspension of CNT's in water after various sonication times is introduced [12].

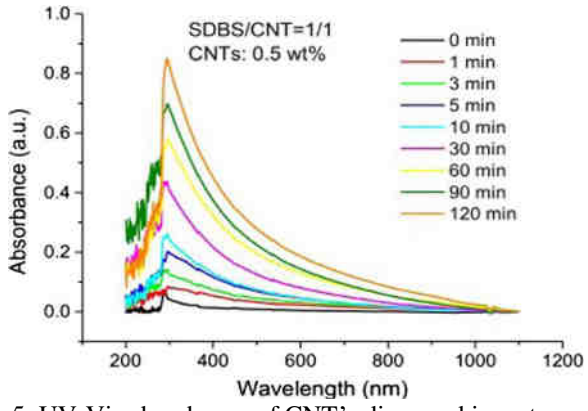

Fig. 5. UV-Vis absorbance of CNT's dispersed in water and exposed to different sonication [12]

Microstructure properties of materials at tiny level are legitimately identified with their structure at the smaller scale and nanoscale level. Li et. al. [13] investigated the improvement of properties of CNT morter corresponding to it microstructure. Significant viewpoint to consider in the microstructure of CNT scattering, Interfacial holding among CNT's and the split spanning the pore size dispersion. Micrographs of carbon nanotubes (Fig. 6) It is saw that the measurement of nanotube is somewhere in the range of 20nm

– 40nm and length is around many microns, bringing about perspective proportion upto 100-1000 [13].

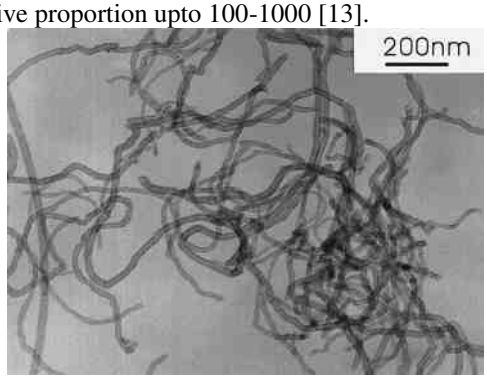

Fig. 6. TEM image of multi-walled carbon nano-tubes [13]

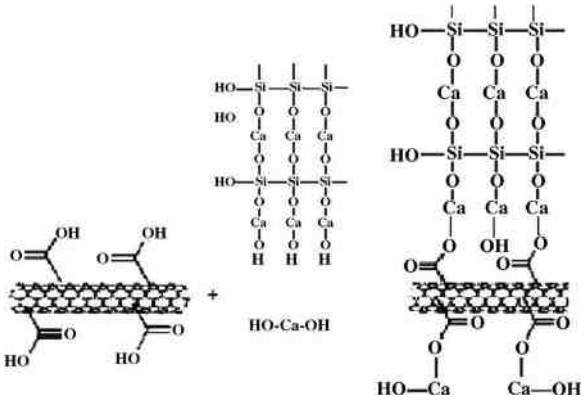

Fig. 7. Reaction between carboxylated nanotube and hydrated production [Ca(OH)2 and C–S–H] of cement[14]

Figure. 7 shows the plan of covalent connections between the gathering of the CNT's surfaces and hydration after effects of the concrete; the reaction plot between carboxylic destructive get-together outwardly of the CNT and a C-S-H concrete thing is showed up.

V. CONCLUSION

OPC is broadly utilized worldwide for building and development; anyway it has restricted auxiliary application because of poor rigidity. Ongoing examination has indicated that the joining of CNT's in Cement is a appropriate method of adoring the strength and other properties. So as to understand the capability of CNT in the development business, further examination can be completed on mortars and cement in genuine scale structure, as to date most tests have been performed on concrete in research center scale. There are numerous holes that should be defeated in seeing how to chose strategy for CNT scattering in cementitious material is affects the microstructure and extreme mechanical properties.

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