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Review

Effect of carbon nanotubes on properties of cement mortars

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HIGHLIGHTS

- Classification of carbon nanotubes.
- Uses and applications of carbon nanotubes.
- Review of synthesis of carbon nanotubes in previous researches.
- Review of various properties like, compressive strength, flexural strength.
- Review of properties like microstructure, Youngs modulus, porosity.

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ABSTRACT

Carbon NanoTubes (CNTs) are primarily elemental carbon consisting of curved graphene layer which consists of a single layer of carbon atoms in a honeycomb structure that may contain varying amounts of metal impurities, depending on the method of manufacture. After various years from its detailed characterization CNTs have grown from a material of dreams to a real world material that has already found its application fields. The production capability for carbon nanotubes is growing every year in an exponential degree and as a consequence the price is steeply descending. In addition to their remarkable strength, which is usually quoted as 100 times that of tensile strength of steel at one-sixth of the weight, CNTs have shown a surprising array of other properties. It has a wide range of its use in various applications like its use in energy sector, medicine sector, environmental sectors, electronics sectors, etc. In Civil Engineering applications CNTs are being effectively used in various research works which remarkably improves the mechanical properties of cement mortars, when added into it.

Published literature has shown that CNTs could be used in manufacturing concrete and mortars. This paper presents an overview of some of the research published on the use of CNT in concrete/mortars. Effect of CNTs on properties such as compressive strength, tensile strength, modulus of elasticity, flexural strength, porosity, electrical conductivity and autogeneous shrinkage are presented in this paper.

Contents

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1. Introduction

Until the mid-1980s pure solid carbon was thought to exist in only two physical forms, diamond and graphite, called allotropes, which have different physical structures and properties however their atoms are both arranged in covalently bonded networks. In 1985 a group of researchers led by Richard Smalley and Robert Curl of Rice University in Houston and Harry Kroto of the University of Sussex in England made an interesting discovery. They vaporized a sample of graphite with an intense pulse of laser light and used a stream of helium gas to carry the vaporized carbon into a mass spectrometer that showed peaks corresponding to clusters of carbon atoms, with a particularly strong peak corresponding to molecules composed of 60 carbon atoms, C60. This soccer ball shaped C60 molecule was named "buckerminsterfullerene" or "buckyball" for short. The unique geometric properties of this new allotrope of carbon did not end with soccer shaped molecules, it was also discovered that carbon atoms can form long cylindrical tubes also. These tubes were originally called "buckytubes" but now are better known as carbon nanotubes or CNT for short. These molecules are shaped like a tube; imagine a sheet of graphite ("graphene sheet") or chicken wire rolled into a tube. It was the Iijima observation of the multiwall carbon nanotubes in 1991 that heralded the entry of many scientists into the field of CNT, stimulated by the remarkable one-dimensional (1D) quantum effects predicted for their electronic properties, and subsequently by the promise that the remarkable structure and properties of carbon nanotubes might give rise to some unique applications. Whereas the initial experimental Iijima observation was for multi-wall nanotubes (MWNTs), it was less than 2 years before single-wall carbon nanotubes (SWNTs) were discovered experimentally by Iijima and his group. Since the first report on CNTs by Iijima in 1991, numerous attempts have been made to strengthen materials (especially polymer-based materials) with nanotubes [1–3]. In the last few years, the effect of CNT-additions to cement-based materials has also been investigated.

Carbon nanotubes can be categorized into two major forms: single walled carbon nanotubes and multi walled carbon nanotubes. Single-Walled Carbon NanoTubes (SWCNTs) are basically tubes of graphite and are normally capped at the ends, as shown in Fig. 1, although the caps can be removed [4]. The caps are made by mixing in some pentagons with the hexagons and are the reason that nanotubes are considered close cousins of buckminsterfullerene, as shown in Fig. 2, a roughly spherical molecule made of sixty carbon atoms that looks like a soccer ball and is named after the architect Buckminster Fuller. The theoretical minimum diameter of a carbon nanotube is around 0.4 nanometres, which is about as long as two silicon atoms side by side. Average diameters tend to be around the 1.2 nanometre mark, depending on the process used to create them. SWNTs are more pliable than their multi-walled counterparts and can be twisted, flattened and bent into small circles or around sharp bends without breaking. They can be conducting, like metal (such nanotubes are often referred to as metallic nanotubes), or semiconducting, which means that the flow of current through them can be stepped up or down by varying an electrical field. On the other hand multi-walled carbon nanotubes are concentric cylindrical graphite tubes made out of SWNTs. Although it is easier to produce significant quantities of MWNTs than SWNTs, their structures are less well understood than single-wall nanotubes because of their greater complexity and variety as shown in Fig. 3. MWNTs always (so far) have more defects than SWNTs and these diminish their desirable properties

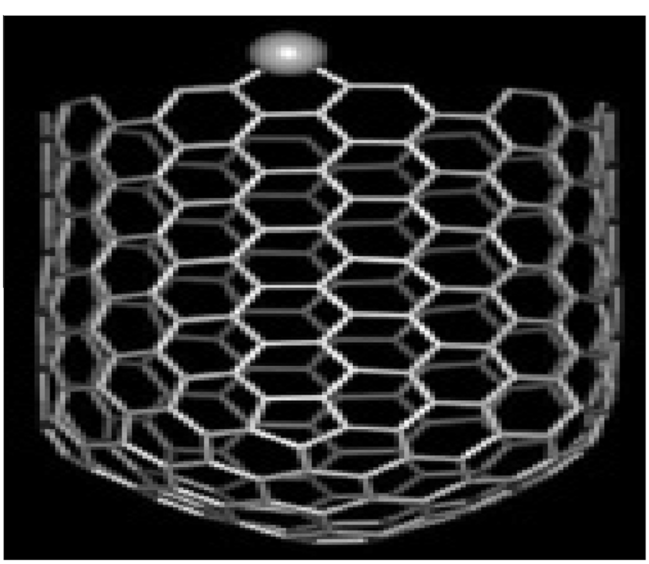

Fig. 1. Simulated structure of a carbon nanotube. Courtesy of Richard Smalley's picture gallery (http://www.cmp-cientifica.com).

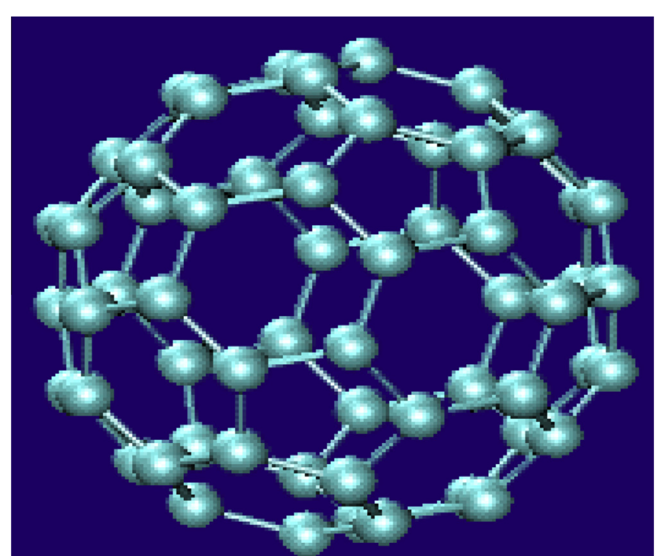

Fig. 2. Buckminsterfullerene. *Source*: Chem Library, Imperial College of Science, Technology and Medicine, UK (http://www.cmp-cientifica.com).