International Journal of Latest Research in Engineering and Technology (IJLRET)
ISSN: 2454-5031
www.ijlret.com || Volume 02 - Issue 05 || May 2016 || PP. 81-84

Use of Nanomaterials in Concrete

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Abstract- Concrete is a macro-material strongly influenced by its nano-properties.The addition of nano-silica (SiO2) to cement based materials can control the degradation of the calcium-silicatehydrate 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.

Keywords- nano,carbon,strength,concrete,micro

I. INTRODUCTION

Nanomaterials can be defined as those physical substances with at least one dimension between 1…150 nm (1 nm = 10–9 m). The nanomaterials 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 nanoscience representss 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 nanoparticles .

II. NANOTECHNOLOGY

Nanotechnology considers two main approaches: (a) the ‘‘top down” approach in which larger structures are reduced in size to the nanoscale while maintaining their original properties without atomic-level control (e.g., miniaturization in the domain of electronics) or deconstructed from larger structures into their smaller composite parts and (b) the ‘‘bottom-up” approach, also called ‘‘molecular nanotechnology” or ‘‘molecular manufacturing” (example: www.nano.gov) in which materials are engineered from atoms or molecular components through a process of assembly or self-assembly. Nanotechnology encompasses two main approaches: the “top-down” approach, in which larger structures are reduced in size to the nanoscale while maintaining their original properties without atomic-level control or deconstructed from the larger structures into their smaller composite parts. The “bottom-up” approach is also called as the “molecular manufacturing” or “molecular nanotechnology”. In this approach materials are engineered from atoms or molecular components through a process of assembly or self assembly. While most contemporary technologies rely on the “top-down” approach, molecular nanotechnology holds the great promise for breakthroughs in materials and manufacturing electronics, medicine and health care, energy, biotechnology, information technology, and national security.

III. TYPES OF NANOMATERIALS

The extraordinary chemical and physical properties of materials at the nanometer scale enable novel applications ranging from structural strength enhancement to self-cleaning properties. Consequently, various nanomaterials have been used in the concrete to make it a real “smart” material.

1. Iron Oxide Nanoparticles (Nano-Fe_2O_3)

Although copper, cobalt and nickel are highly magnetic materials but they have very limited applications due to their toxicity and susceptibility to oxidation. Unlike these, iron oxide nanoparticles have attracted extensive interest due to their super paramagnetic properties and their potential applications in many fields.

These are two main forms of iron oxide nanoparticles. They are magnetic($Fe_2 0_3$) or its oxidized form maghemite($Fe_2 0_3$). They are shown in **fig.1**

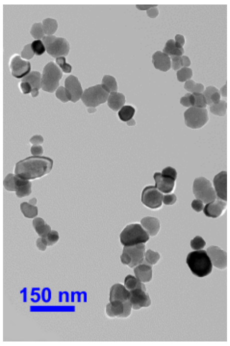

Fig .1: Iron oxide nanoparticles (www.googleimages.com)

They have many applications in construction industry, but of particular interest is as a colouring and as a anti-corrosion agent in construction materials and coatings. Iron oxide nanoparticles have very good UV blocking capabilities making these nanoparticles ideal for glass applications ranging from glass coatings to cunglasses. They also allow for better dispersion in paints and coatings, especially in high gloss and automotive applications.

2. Silver Nanoparticles

The nanosilver will affect, in contact with bacteria, viruses and fungi, the cellular metabolism and inhibit cells growth. The nanosilver inhibits multiplication and growth of bacteria and fungi, which causes infection, odour, itchiness and sores. The core technology of nanosilver is the ability to produce particles as small as possible and to distribute these particles very uniformly. When the nanoparticles are coated on the surface of any material, the surface area is increasing several million times than the normal silver foil. Silver is an especially attractive metal due to its remarkable size and shape dependent optical properties, highest efficiency of Plasmon excitation, and highest electrical and thermal conductivity in the bulk among all metals. These special properties have led to promising applications of silver nanoparticles catalysis for the selective oxidation of styrene, environmentally friendly antimicrobial coatings, real-time optical sensors, printed electronics and photonics. Silver nanoparticles are nanoparticles of silver i.e. silver particles of between 1 nm and 100 nm in size. They are shown in Fig.2.

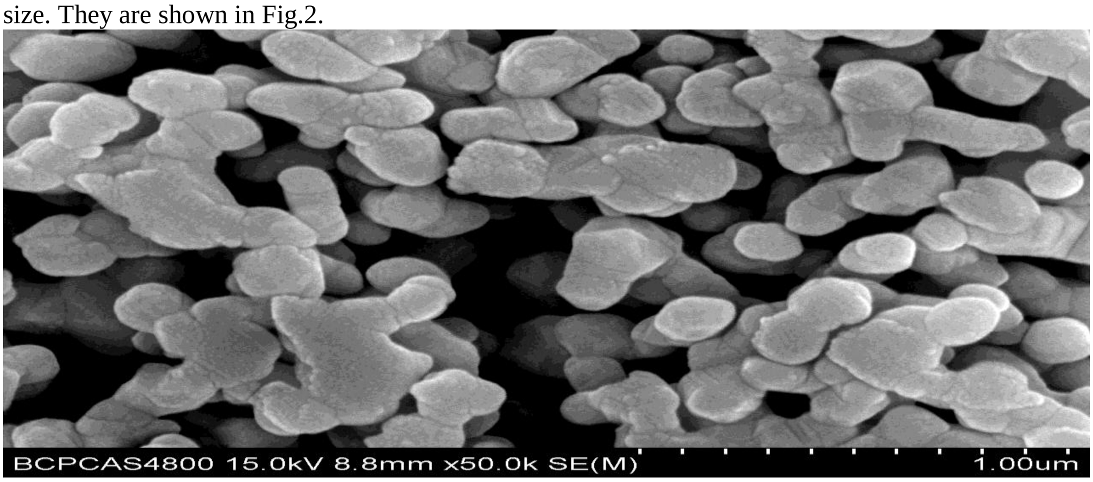

Fig.2: Silver Nanoparticles (www.googleimages.com)

Over the last decade silver nanoparticles have found applications in catalysis, optics, electronics and other areas due to unique size-dependent optical, electrical and magnetic properties. Currently most of the applications of silver nanoparticles are in antibacterial/antifungal agents in biotechnology and bioengineering, textile engineering, water treatment, and silver-based consumer products.

3. Carbon Nano Tubes (CNTs)

Carbon nanotubes are a form of carbon having a cylindrical shape, the name coming from their nanometre diameter. They can be several millimetres 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.3**:

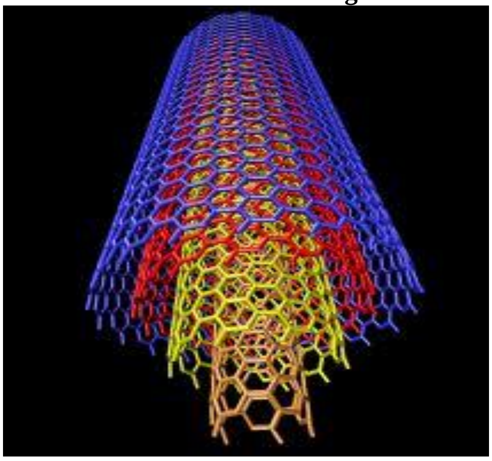

Fig.3: Carbon nanotubes (www.googleimages.com)

Carbon Nanotubes are the potential candidates for the use as nanoreinforcements 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)**

PROPERTIES OF CARBON NANOTUBES

(A)Strength

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.

(B) Hardness

Diamond is considered to be the hardest material. Under conditions of high temperature and high pressure graphite transforms into diamond. One study succeeded in the synthesis of a super-hard material by compressing SWNTs (Single walled Nano tubes) to above 24 GPa at room temperature. The hardness of this material was measured with a nanoindenter as 62-152 GPa.

(C)Thermal

All nanotubes are expected to be very good thermal conductors along the tube, exhibiting a property known as "ballistic conduction '', but good insulators laterally to the tube axis. Measurements showed that a SWNT has a room temperature thermal conductivity along its axis of about 3500 $Wm^{-1}k^{-1}$.

APPLICATIONS OF CARBON NANOTUBES

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 nanomaterial 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.

CONCLUSION

Nanomaterials (a nanometer, nm, and 10^{-9} m) have smallest particle size and largest surface area. Nanomaterials have great potential in improving properties of the concrete. Until today concrete has primarily been seen as a structural material but nanotechnology can help to make it as multipurpose “smart” functional material.They can improve the overall performance of concrete since they have high surface area to volume ratio providing the potential for tremendous chemical reactivity.

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