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Thrust Investigation on Nanotechnology in Structural Building

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Abstract

Nanotechnology can be seen in the field of biomedical, electronics robotics. In civil engineering it has applications in concrete for reducing segregation, use of copper nano-particles in low carbon content, the utilization of nano-sensors in development is amazing. The present paper surveys the utilization of nanotechnology in the field of structural building and development. Additionally, unique accentuation is set on the future utilization of nanotechnology in geotechnical designing. The nanotechnology can be used to develop a novel, smart, eco- and environment- friendly construction material towards in civil engineering.

The goal of this review is to inspect the part of nanotechnology in structural designing applications. Additionally, it shows the utilization of instruments to achieve material properties of nano-scale. Moreover, it has been finding that better understanding and designing of complex structures made by concrete, steel or composite materials at nano-level. This paper also shows the relevance of nanotechnology in the region of cement based materials, their composites

Keywords: Nanotechnology; Nano-sensors, Carbon nano-tubes, Polymer Nano-Composites, Nano-sensors

1. INTRODUCTION

Nanotechnology is the re-engineering of materials and devices by controlling the matter at the atomic level [1]. The convergence of experimental advances such as the invention of scanning tunnelling microscope is considered as the major cause for the emergence of nanotechnology.

The properties of materials are dramatically affected under a scale of nanometre. It deals with the particles of size at nano-scale i.e., 10^{-9} m. Nanotechnology is a field that is dominated by developments in basic physics and chemistry research and of biomedical [2, 3] are used to provide materials and structures. However, nanotechnology is the most active research areas with both new science and pioneering applicationsStructure. In the present situation, nanotechnology is picking up prevalence in the field of structural designing and construction. In view of that, the present paper reviews the use of nanotechnology in the field of civil engineering and construction.

1.1. Different Nanoparticles in Constructions

By the use of granulated particles and nano-size ingredients such as alumina and silica concrete are made stronger, more durable. In construction, following three granulated (nanosized) particles stand out their application:

- Carbon nano-tubes (CNT's)

- Nano Silica (SiO_2)
- Titanium dioxide (TiO_2)

1.1.1 Carbon Nano-tubes (CNT's)

CNTs are tubular nano-structures with a diameter of a few nanometres and a large length/diameter aspect ratio. Its atomic structure consists of a single or several concentric hexagonal lattices of carbon atoms linked by sp^2 bonds and separated by 0.34 nm. Due to the hexagonal lattice and sp^2 bonds between carbon atoms, CNTs have highly advantageous properties. Carbon nano-tubes are cylindrical in shape with young modulus five times more than that of the steel [4] and density $1/5^{th}$ of the steel. The high conductivity, elastic deformability, strength, surface chemistry, high stability is some of the properties that CNT's provide due to their structure and topology [5].

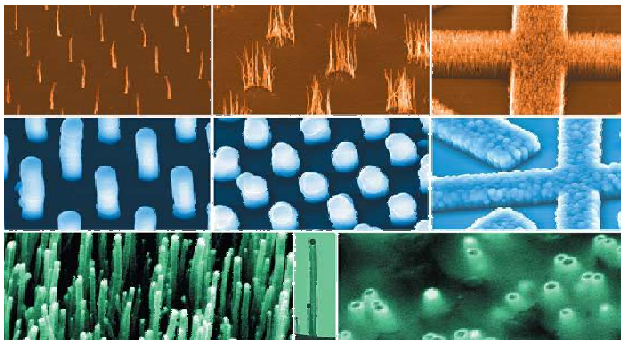

Figure 1 Nanotube (after NASA, 2008)

It is also used to strengthen the concrete, where titanium dioxide is widely used as a white pigment. It has the ability to oxidize oxygen or organic materials therefore, added to paints, cements etc. Additionally, when it is exposed to UV light, it become extremely hydrophilic thus used as for anti-fogging coatings.
Three main techniques were reported in CNT production: arc-discharge, laser ablation and catalytic growth [6].
In research, two types of carbon nano-tubes were reported: single-walled carbon nano-tubes (SWCNT) and multi-walled carbon nano-tubes (MWCNT), whose differences remain mainly in their overall thickness.
Due their specific structure, nano materials can be either metallic conductors or semiconductors [7]. Thus, CNTs can also be used to increase the conductivity of the composite material.

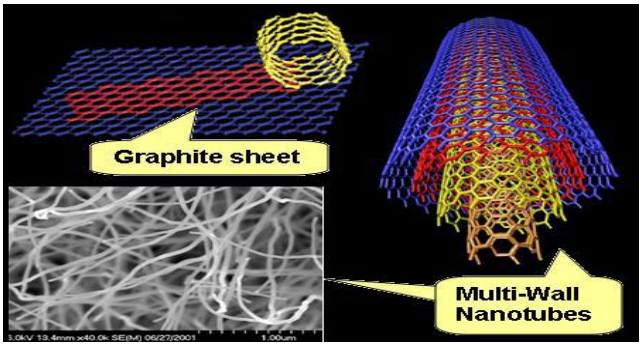

Figure 2 Graphite sheet of nanotube (after Nanopedia, 2008)

1.1.2 Nano Silica (SiO_2)

Silicon dioxide (SiO2) or Nano-Silica and its colloidal structure are termed as Silica Fume.Nano Silica mixed with cement can improve mechanical properties [8] and can control the defilement of the significant C-S-H (Calcium-Silicate-Hydrate) reaction of cement. This can hinder water entrance and along these lines incite changes in quality. The reward of using SF include elevated early compressive strength, more tensile, flexural strength and modulus of elasticity, enhanced durability, low permeability. They increase quality and furthermore offering the benefit of watching uneasiness levels through the estimation of range electrical resistance.
The concrete with Silica Fume has less coarse pores than ordinary concrete, thus a reduction of porosity was observed due to the micro dimension of these particles. Taking advantages of these potentialities of the use of Silica Fume, its application in the production of high-performance concrete for highway bridges, parking decks or marine structures was analysed [9]. The use of Nano Silica in concrete production has a high potential to improve a wide range of fundamental properties in concrete, such as strength, workability setting time, heat of hydration, fire resistance or leaching and behaviour under aggressive environments.

1.1.3 Titanium Dioxide (TiO_2)

Another type of nano particle added to concrete to improve its properties is titanium dioxide (TiO_2) [10]. TiO_2 is a white colour and can be utilized as a brilliant intelligent covering. TiO_2 separates natural contaminations, unstable natural mixes, and bacterial layers through capable synergist responses. It is incorporated in sun-block to block UV light and it is added to paints, cements and windows for its sterilizing properties since TiO_2 separates natural poisons, unstable natural mixes, and bacterial films through capable synergist reactions [11]. Additionally, it is hydrophilic and therefore gives self-cleaning properties to the applied surfaces. In this procedure rain water is pulled in to the surface and structures sheets which gather the toxins and soil particles beforehand severed down and washes them. The resulting concrete has a white colour that retains its whiteness very effectively [12].

2. Applications of Nanotechnology Civil Engineering and Construction

The major applications of nanotechnology civil engineering and construction are:
(i) Concrete for decreasing isolation in self-compacted concrete [13]
(ii)Cu Nano-particles in low carbon HPS power [14]
(iii)Sensors with Nano technology [15]
(iv)Water cleaning framework by supplanting the utilization of granulated particles of carbon in filtration with purifiers like Nano Ceram-Pac (NCP)[16]
(v) Steel with Nanotechnology
(vi)Nanotechnology in Glass
(vii) Nano-Composite Polymer

2.1. Nanotechnology and Concrete

Concrete is one of the most common and widely used construction materials. The quick improvement of new procedures makes it feasible to concentrate the properties of cementitious materials at miniaturized scale/nano-scale. Expansion of nano-scale materials into bond could enhance its execution. SiO_2 could altogether build the compressive for concrete, containing expansive volume fly powder, at early age and enhance pore estimate dissemination by filling the pores among cumbersome fly fiery remains and bond particles at nano-scale [17]. The scattering of nebulous nano silica is utilized to enhance isolation resistance for self-compacting solid [18]. The addition of little amount of carbon nanotube (1%) by weight could increase both compressive and flexural strength [19]. Breaking is a significant problem for structures but after addition of nano particles materials repair themselves when they experience water. The hydrogen in the water helps the particles from the broken hydrogen bonds. Cracks will repair themselves when water is added [20,21]. The self-mending polymer could be particularly material to settle the small-scale splitting in scaffold docks and segments.

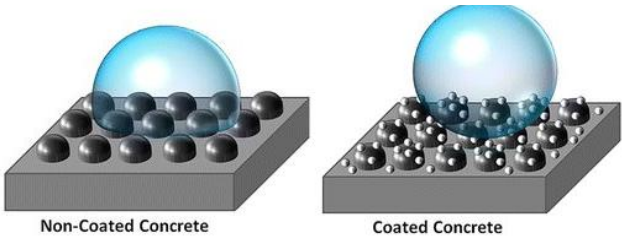

Figure 3 Coated and non-coated concrete

2.2. Nanotechnology and Steel

In steel, major problem is weariness, when the steel is subjected to cyclic stacking, for example, in scaffolds and towers. According to the exploration is concerned, the expansion of copper nano-particles lessens the surface unevenness which at last restrains the quantity of stress risers and exhaustion breaking. Besides, it has been accounted for that vanadium and molybdenum nano-particles can enhance the crack issues related with high quality bolts [22]

2.3. Nanotechnology and Coatings

Chemical Vapors deposition plays a very important role in coatings. In order to produce or develop a layer at the base material which can provide a surface of the desired protective or functional properties dip, meniscus, spray, plasma coatings are practiced. One of the major goal or objectives of research being carried out for this purpose is to achieve the endowment of the self- healing [23] capabilities through a process of self-assembly.

2.4. Bactericidal Capacity

The fungi and bacteria proliferation has been one of the main causes responsible for construction materials degradation and also for health problems [24,25]. We should more focus on green compound synthesis [26-28] [28-30] to avoid such problems. The expansion of TiO_2 powder with a normal size 21 nm (30% rutile and 70% anatase) to a bacterial settlement was adequate to pulverize all the bacteria [29].

Various theories and explanations have been proposed for different nanoparticles for their microbicidal activity (Fig. 2) and have been studied on the basis of morphological and structural changes in the bacterial cells. Nanoparticles are shown to have the ability to anchor to the bacterial cell wall and subsequently penetrate it, thereby causing structural changes in the cell membrane permeability leading to cell death.[30]

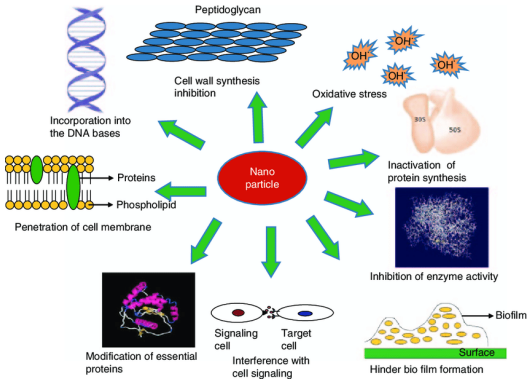

Figure 4 Mechanisms for antibacterial activity of nanoparticles

2.5. Nanotechnology in Glass

Broad research is being done on the utilization of nanotechnology to glass [31]. Titanium dioxide (TiO_2) can be utilized as a part of nano shape to coat the glasses to import the cleaning and hostile to fouling properties of TiO_2. Besides, TiO_2 is

hydrophilic and this fascination in water shapes sheets out of rain drops, and therefore, self-cleaning glass is available in the market.

2.6. Nano-Composites Polymer

A standout amongst the most intriguing interdisciplinary regions in structural designing control is dirt-polymer composites. This innovation has gotten awesome consideration in the territory of nano-composites examine. It offers immense change in an extensive variety of physical and building properties for polymers with bring down rate of filler. This nano-composite approach has favorable circumstances over the purported fiber fortified composites in the low filler stacking range. Mud-polymer nano-composites have enhanced physical and building properties, including fire retardancy, hindrance resistance, and particle conductivity [32]. This polymer composite method can likewise be valuable for water-dissolvable hydrophilic/hydrophobic useful monomer frameworks for the planning of polymer/silicate half and half nano-materials.

2.7. Nanotechnology in Nano-sensor

Nano and miniaturized scale electrical mechanical frameworks (MEMS) sensors have been created and utilized as a part of development to screen or potentially control nature condition and the materials/structure execution. The small-scale sensor having ranges 10^{-4} to 10^{-2} m [33] could be installed into the structure amid the development procedure. The piezoceramic-based multi-utilitarian gadget has been connected to screen early age solid properties, for example, dampness, temperature, relative mugginess and early age quality development [34,35]. The sensors can be utilized to screen solid consumption and breaking. The shrewd total can also utilize for structure wellbeing checking. The unveiled framework can screen interior burdens, breaks and other physical strengths in the structures amid the structures' life. It is prepared for giving an early indication of the soundness of the structure before a mistake of the structure can happen.

3. Future Dispute and Trends

The nanotechnology clearly has the potential to be the key to a brand-new world in the field of construction and building materials. The application of Nano silica in cement and concrete production promises larger potential of studies showing the mechanical behaviour of some structural elements, such as beams, columns or slabs.
The area of coatings is now the issue with more known applications in the construction industry. Although it has lower impacts on the structural activities of buildings, the chance to give structures anti-corrosion protection, self-cleaning and depleting effects should be considered. In this sense, future technical research should be focused on the purpose of nano-coatings over different surfaces and trying of their behaviour under harsh environments. We get green revolution via sustainable use of green technology. [36-39]

Nano-sensors are also an attractive issue although a vast number of new publications and tests are required in order to be ready for huge structural applications. The nanotechnology turns into a twofold edge weapon to the generation business. More research and practice endeavors are required with brilliant outline and arranging, development tasks can be made manageable and, in this way, spare vitality, lessen asset utilization, and maintain a strategic distance from harms to condition. It is important to set up a framework to distinguish the ecologically cordial and practical of development nonmaterial and to maintain a strategic distance from the utilization of unsafe materials later on.

4. Conclusion

Nanotechnology has tremendous potentials in construction industry. The important developments made in concrete technology are ultra-high strength concrete, photocatalytic concrete, self-heating concrete, bendable concrete and concrete containing CNTs. It is a well-known fact that nano TiO2 on UV irradiation can be used as an effective way to reduce the contaminants and enhance environmental safety. An extensive literature review was conducted into the properties and applications of nano-materials that make them useful as a part of the construction materials. The present paper discusses the present and futuristic applications of nanotechnology in civil engineering Further, mechano-concoction exercises in nano level of the materials in charge of the adjustments in properties are talked about to give the science behind change of

material properties. It is discovered that the normal minerals can likewise be dealt with as nano particles for delivering nano bond.

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