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A REVIEW ON THE USE OF NANOTECHNOLOGY AND NANOMATERIALS IN CIVIL ENGINEERING

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ABSTRACT

Nanotechnology and Nanomaterials is one of the most active research areas with both science and engineering. Thus, this is nanotechnology will help us control the smallest of the material, therefore, avoid the errors occurs or problems in the field of civil engineering. The Architecture, Engineering, and Construction industry can take the advantage of applications of nanotechnology and nanomaterial. This review Paper shows there are different uses of nanotechnology in building materials like concrete, carbon, nanotube, steel, wood, coating, glass ,fire protection ,thermal insulation and green building etc. different nanomaterial are used in the construction material like Titanium dioxide (TiO2), nano silica(ns), polycarboxilates,Zirconium Oxide Nanoparticles (ZrO2),Silver Nanoparticles (Ag),Aluminum Oxide Nanoparticles (Al2O3),Zirconium Oxide Nanoparticles (ZrO2),Wolfram (Tungsten) Oxide Nanoparticles (WO3)etc.by using these materials and nanotechnology we can save time and also energy .this is the advanced technology which can very useful in the civil or construction industry.

Keywords: Nanotechnology , Nanomaterial, Titanium dioxide (TiO2), nano silica(ns), polycarboxilates, (ZrO2),(Ag), (Al2O3), (ZrO2), (WO3)

I. INTRODUCTION

Nanotechnology is the use of very small particles of material to create new large scale materials. Nanotechnology is use in science as well as in technologies also. It have already been in development for many years.The Architecture, Engineering, and Construction industry might accommodate broad applications of nanotechnology and nanomaterial. These products can be used for design and construction processes in many areas. Nanotechnology is the area which is used to improve the mixture design, performance and production of cement-based materials. Materials composed of nano-sized particles displays unique physical and chemical properties compared to those with normal particle sizes. Concrete is stronger, more durable and more easily placed, steel tougher and glass self-cleaning. Increased strength and durability of the product. Nanomaterials can be defined as those physical substances with at least one dimension between 1…150 nm (1 nm = 10–9 m). Currently, the use of nanomaterials in construction is reduced, mainly for the following reasons: the lack of knowledge concerning the suitable nanomaterials for construction and their behavior; the lack of specific standards for design and execution of the construction elements using nanomaterials; the reduced offer of

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nanoproducts; the lack of detailed informations regarding the nanoproducts content; high costs; the unknown of health risks associated with nanomaterials.

II. NANO TECHNOLOGY IN CONSTRUCTION INDUSTRY

Nanotechnology can be used for design and construction processes. Nanotechnology can generate products with their characteristics to improve the current construction materials. For example, new structural materials with unique properties, lighter and stronger composites, fire insulator, sound absorber, low maintenance coating Nano sized sensors solar cells etc.

The areas of application of nanotechnology in civil engineering and the science & technology behind the improved performance.

1 Nanotechnologies for Concrete

Concrete is a macro-material which has its nano-properties. The additions of nano-silica (SiO2) to cement for control the degradation of the calcium-silicate hydrate reaction to improve in durability. Micro and nanostructure resulting in improved mechanical properties. Nanotechnology is used to studying its properties like hydration reaction, alkali silicate reaction (ASR) and fly ash reactivity. For concrete containing large volume fly ash, at early age it can improve pore size distribution by filling the pores between large fly ash and cement particles at Nano scale.It is also been reported that adding small amount of carbon nanotube (1%) by weight could increase both compressive and flexural strength (Mann,2006)

2 Nanotechnologies for Steel

Steel is major part in the construction industry since 19^{th} to 20^{th} century and it is widely available for the construction purpose. Fatigue is a issue that can lead to the structural failure of steel subject to cyclic loading, such as in bridges or towers. The stress is lower than the yield stress of the material and due to that shortening of useful life of the structure is occurs. this can be avoided by taking the regular inspection. The addition of copper nanoparticles reduces the surface unevenness of steel and it is more efficient materials use in construction subjected to fatigue issues (Mann, 2006) and The addition of nanoparticles of magnesium and calcium leads to an increase in weld toughness. The carbon nanotubes have little use as an addition to steel because of their inherent slipperiness is occurs ,due to the graphitic nature, making them difficult to bind to the bulk material (Mann, 2006).

3 Nanotechnologies for Wood

Wood is composed of nanotubes surfaces at the nanoscale. It is sustainable construction as both the production and the part of a renewable cycle. Due to its natural origins, wood is leading the way in cross-disciplinary research and modelling techniques. wood is highly water repellent coating which result of the combination of silica and alumina nano particles and hydrophobic polymers.

4 Nanotechnologies for Glass

Glass is Fire-protective which another application of nanotechnology. Glass panel (an interlayer) is formed of fumed silica (SiO2) nanoparticles which turns into a rigid and fire shield when heated. Because of the hydrophobic properties of TiO2, it can be applied in self-cleaning windows. To prevent sticking of pollutants, and thus reduce a maintenance costs .Nano-TiO2 coatings can be applied to building exteriors.

5 Nanotechnologies for Coatings and Paitings

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Nanotechnology is applied to paints in order to avoid the corrosion under insulation because of hydrophobic and repels water from the metal pipe and can also protect metal from salt water attack. Coatings have self healing capabilities through a process of "self assembly". Eg. Glazing.The coatings have Nano particles or Nano layers have been developed for different purposes like protective or anti-corrosion coatings for mechanism; self-cleaning, thermal control, energy saving, anti-reflection coatings for glass/windows; easy-to-clean, antibacterial coatings for work surfaces; and more durable paints. The coating is consist of two stages. First, using a „photocatalytic" process, nanosized TiO2 particles in the coating react with ultra-violet rays from natural daylight to break down and disintegrate organic dirt. Secondly, the surface coating is hydrophilic, which lets rainwater spread evenly over the surface and „sheet" down the glass to wash the loosened dirt away. It can therefore reduce airborne pollutants when applied to outdoor surfaces. TiO2 is used to coat glazing because of its sterilizing and anti-fouling properties.

6 Nanotechnologies for Thermal Insulation

Moisture is obtained from Micro and nonporous aerogel materials. The uses hydrophobic nanoporous aerogel structure is for ultra-thin wall insulation. Aerogel is form of silica which has application for transparent insulation.The energy saving product is nothing but use of Micro systems offer the possibility of monitoring and controlling the internal environmental condition of buildings.

7 Nanotechnologies for Fire Protection

Fire protection is done by providing coating produced by a spray-on cementitious process. Nano-cement some properties to create a tough, durable, high temperature coatings. This is achieved by the mixing of carbon nanotubes with the cementious material.

8 Nanotechnologies for Structural Monitoring

Nano and microelectrical mechanical systems (MEMS) sensors have been developed and used in construction to monitor and/or control the environment condition and the materials/structure performance.One advantage of these sensors is their dimension. Nanosensor ranges from 10-9 m to 10-5m. The micro sensor ranges from 10-4 to 10-2 m (Liu *et al.*, 2007). These sensors could be embedded into the structure during the construction process. The sensors can also be used to monitor concrete corrosion and cracking.The smart aggregate can also be used for structure health monitoring. The disclosed system can monitor internal stresses, cracks and other physical forces in the structures during the structures' life. It is capable of providing an early indication of the health of the structure before a failure of the structure can occur.

9 Nano Technology and Green Building

Nanotechnology, the manipulation of matter at the molecular scale, is bringing new materials and new possibilities to industries as diverse as electronics, medicine, energy and aeronautics. Our ability to design new materials from the bottom up is impacting the building industry as well. New materials and products based on nanotechnology can be found in building insulation, coatings, and solar technologies. Work now underway in nanotech labs will soon result in new products for lighting, structures, and energy. In the building industry, nanotechnology has already brought to market self-cleaning windows, smog-eating concrete, and many other advances. But these advances and currently available products are minor compared to those incubating in the world's nanotech labs today. There, work is underway on illuminating walls that change colour with the flip of a

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switch, nano composites as thin as glass yet capable of supporting entire buildings, and photosynthetic surfaces making any building facade a source of free energy.

III.NANO MATERIALS

Nanomaterial is defined as the smallest material which has less than 100nm in size. One nanometer is 10-9 meters or about 3 atoms long. For comparison, a human hair is about 60-80,000 nanometers wide.

In general in nanotechnology following points are to be considered that is Small size, measured in 100s of nanometers or less , Unique properties because of the small size ,Control the structure and composition on the nm scale in order to control the properties. Currently, the use of nanomaterials in construction is reduced, mainly for the different reasons.

3 Types of Nano Materials

There are different types of nanomaterials are available for different purposes which is for the construction or any other purpose which is belonging to nano technology.

- Titanium dioxide (TiO2)
- Carbon nanotubes (CNT's)
- Nano silica(ns)
- Polycarboxilates
- Zirconium Oxide Nanoparticles (ZrO2)
- Silver Nanoparticles (Ag)
- Aluminum Oxide Nanoparticles (Al2O3)
- Zirconium Oxide Nanoparticles (ZrO2)
- Wolfram (Tungsten) Oxide Nanoparticles (WO3)

3.1Titanium dioxide (TiO2)

TiO2 is a white pigment and can be used as an excellent reflective coating. It is incorporated, as nano particles and it is added to paints, cements and windows for its sterilizing properties since TiO2 breaks down organic pollutants, volatile organic compounds and bacterial membranes through powerful catalytic reactions. It can therefore reduce airborne pollutants when applied to outdoor surfaces. Additionally, it is hydrophilic and therefore gives self cleaning properties to surfaces to which it is applied. The process by which this occurs is that rain water is attracted to the surface and forms sheets which collect the pollutants and dirt particles previously broken down and washes them off. The resulting concrete, already used in projects around the world, has a white colour that retains its whiteness very effectively unlike the stained buildings of the material's pioneering past.

3.2Carbon nanotubes (CNT's)

A further type of nanoparticle, which has remarkable properties, is the carbon nano tube (CNT) and current research is being carried out to investigate the benefits of adding CNT's to concrete. Carbon nanotubes are a form of carbon that was first discovered in Russia but came into use in the late ninety's in Japan. They are cylindrical in shape, as shown in figure below, and their name comes 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). They have 5 times the Young's modulus and 8 times (theoretically 100 times) the

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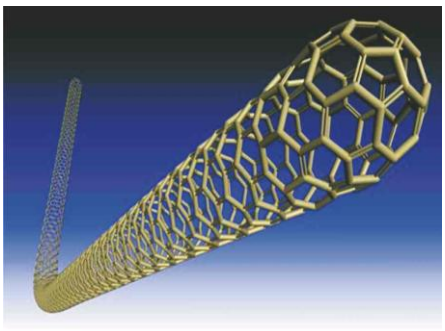
strength of steel while being 1/6th the density. The addition of small amounts (1% wt) of CNT's can improve the mechanical properties of samples consisting of the main Portland cement phase and water. Oxidized multi-walled nanotubes (MWNT's) show the best improvements both in compressive strength (+ 25 N/mm2) and flexural strength (+ 8 N/mm) compared to the reference samples without the reinforcement. It is theorized the high defect concentration on the surface of the oxidized MWNTs could lead to a better linkage between the nanostructures and the binder thus improving the mechanical properties of the composite rather like the deformations on reinforcing bars.



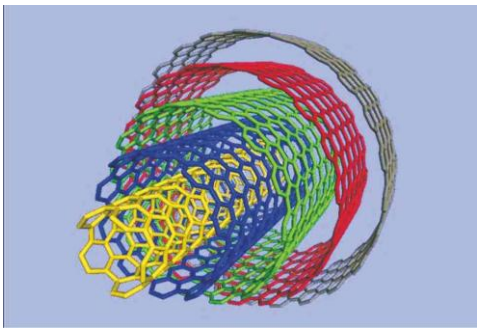


Fig.3.2.1computer-generated model of a carbon nanotube ***fig.3.2.2computer-generated model of multiwalled carbon nanotubes***

3.3 Nano Silica(ns)

Finally, fibre wrapping of concrete is quite common today for increasing the strength of pre- existing concrete structural elements. Advancement in the procedure involves the use of a fibre sheet containing nano-silica particles and hardeners. These nanoparticles penetrate and close small cracks on the concrete surface and, in strengthening applications, the matrices form a strong bond between the surface of the concrete and the fibre reinforcement. In the strengthening process pre-cut carbon tows (fibres) and sheets impregnated with the matrix are placed on the prepared concrete surface and bonded using grooved rollers. The ability of the samples to sustain load after cracking is greatly improved by the carbon tows and both the matrix and the interface are durable under wetting and drying and scaling (scraping) conditions. Additionally, there is no decrease in the maximum load capacity after repeated cycles of wetting and drying or scaling

3.4 Polycarboxilates

The material behaves like a thick fluid and is made possible by the use of polycarboxylates (a material similar to plastic developed using nanotechnology). SCC mixes, which contain a high content of fine particles, need a very effective dispersing system in order to be fluid and workable overtime at low water/cement ratio (high W/C ratios would lead to risk of segregation) and only polycarboxylates can meet these requirements. In addition, while long term strengths of conventionally super plasticized concrete are very high, the very early strengths, especially in winter, are not high enough for a quick and safe removal of formwork and steam curing is therefore used to accelerate the hydration of cement. This can be eliminated in the precast industry through the use of the latest generations of polycarboxylates resulting in further time and energy savings.

3.5 Zirconium Oxide Nanoparticles (ZrO_2)

The nano Zro2 powder is added to cement then due to that strength is increases. Nano Zro2 particles is white powder of high purity. It appears oblique crystal at low temperature and shows tetragonal crystal formation at high temperature. Nano ZrO2 is soluble in sulfuric acid, hydrofluoric acid and has good thermal-chemical

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stability. When at high temperature, it has electrical conductivity and good strength and toughness. Nano ZrO2 also possesses good mechanical, thermal, electrical and optical properties .

3.6 Silver Nanoparticles (Ag)

Silver Nanoparticles will affect, in contact with bacteria, viruses and fungi. The nanosilver inhibits multiplication and growth of bacteria and fungi, which causes infection, odour, itchiness. In this nanosilver produce the small particles and it varies uniformly. When the nanoparticles are bonded together with other material, the surface area is increasing several million times than the normal silver particles.

3.7 Aluminum Oxide Nanoparticles (Al_2O_3)

Hydration of calcium silicate is occurs due to reaction between Alumina (Al2O3) with calcium hydroxide.

The rate of the pozzolanic reaction is same as amount of surface area available for reaction. It improves higher split tensile and flexural strength due to addition of nano-Al2O3 . The cement could be beneficially replaced in the concrete mixture with nano-Al2O3 particles up to maximum limit of 2.0% with average particle sizes of 15 nm, the optimal level of nano- Al2O3 particles content being achieved with 1.0% replacement (Nazari *et al*., 2010).

3.8 Wolfram (Tungsten) Oxide Nanoparticles (WO_3)

Tungsten trioxide has been developed in the production of electrochromic windows, or smart windows. Ti ts electrically switchable glass that change light transmission properties with voltage.They are used in producing metal tunsten material,Gas sensors,Fire-proofing fabrics, Imaging,Large-area displays, Catalysts, Ceramic pigment , Humidity sensors, Infrared switching devices, High-density memory device, Temperature sensors, used in X-ray screen and fireproof textile, Tungstates, Wastewater treatment,Smart windows etc.

IV. CONCLUSION

Nanotechnology has help improve the quality of and solved many issue with building materials such as concrete and steel. The comparison between the construction material concrete,steel,timber or wood and glass with the properties of carbon nanotube then we get that carbon nanotube has a Young's modulus of 1054 GPa, a tensile strength of 150 GPa and a density of 1.4 g-cm^{-3}. So from this we can conclude that carbon nanotube has strength of 150 times that of steel and at the same time it is six times more lighter than other material. The use of CNTs to improve the efficiency of energy transmission, lighting, and or heating devices.

The use of nanotechnology has also helped formed more efficient also sustainable materials such as self-cleaning and self-repairing concrete. The use of coatings made from nanotechnology helps get better fire-resistance, corrosion protection, insulation, and innumerable other applications. Nanotechnology can even help improve the quality and availability of water. In other words, it creates an environmental challenge to the construction industry as well. Nanotechnology is an extension of the sciences and technologies .The use of micro nano materials (MNMs) in the construction industry should be considered not only for enhancing material properties and functions but also in the context of energy conservation. Using silica nano particles in insulating ceramics and paint/coating that enable energy conservation and solar-powered self-cleaning nano-TiO2-coated surfaces. It is necessary to establish a system to identify the environmentally friendly and sustainable of construction nanomaterials and to avoid the use of harmful materials in the future.

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