APPLICATION OF NANOTECHNOLOGY IN BUILDING CONSTRUCTION INDUSTRY

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ABSTRACT

Important feats in the construction industry were the invention of concrete in ancient Rome, the mass production of steel from the mid-19th century and the mass-production of glass panes that changed from luxury to strength, likely others have similarly small to large changes with time. The paper focuses on questions like: What is nanotechnology? What can nanotechnology mean for the construction industry? Are there presently any commercialized products in construction that make use of nanotechnology? Construction can be defined as a process of converting the basic civil engineering raw materials to the final civil engineering product. Hence if the performance of the basic civil engineering raw materials is enhanced anyhow, the productivity will get increased as to work with those modified materials and the performance of the final civil engineering product will also be improved. Thus, the information presented in this paper is categorized into following main or basic raw materials: Cement, steel, paints, glass and fire protection materials, along with various definitions and basic concept of Nanotechnology.

KEYWORDS:

Nanotechnology, Building materials

I. INTRODUCTION

Nanotechnology is the use of very small particles of material either by themselves or by their manipulation to create new large scale materials. Nanotechnology is not a new science and it is not a new technology, it is rather an extension of the sciences and technologies that have already been in development for many years. Nanotechnology is the re-engineering of materials by controlling the matter at the atomic level. The key in nanotechnology is the size of particles because the properties of materials are dramatically affected under a scale of nano meter [10-9 meter]. Further, as particles become nano-sized the proportion of atoms on the surface increases relative to those inside and this leads to novel properties. Concrete is stronger, more durable and more easily placed, steel tougher and glass self cleaning. Increased strength and durability are also a part of the drive to reduce the environmental footprint of the built environment by the efficient use of resources. This is achieved both prior to the construction process by a reduction in pollution during the

production of materials (e.g. cement) and also in service, through efficient use of energy due to advancements in insulation. Two nano-sized particles that stand out in their application to construction materials are titanium dioxide (TiO2) and carbon nanotubes (CNT's). The former is being used for its ability to break down dirt or pollution and then allow it to be washed off by rain water on everything from concrete to glass and the latter is being used to strengthen and monitor concrete. Owing to many unique characteristics of nanotechnology derived products, newly developed nano based products can significantly reduce current civil engineering problems. Basically, construction deals with hightech materials and processes that have been use in construction. Hence, there is huge scope to apply nano technology in construction materials, which can exhibit, probably one of the most prominent, societal impacts.

Nanotechnology is the use of very small pieces of material by themselves or their manipulation to create new large scale materials. The size of the particles is the critical factor. At the nanoscale (anything from one hundred or more down to a few nanometres, or 10-9m) material properties are altered from that of larger scales. There is a dramatic change in situation and this is what happens at the scale of nanotechnology. Different things start to happen at this level e.g. gravity becomes unimportant, electrostatic forces take over and quantum effects get in. Another important aspect is that, as particles become nano-sized, the proportion of atoms on the surface increases relative to those inside and this leads to change in the properties. Knowledge at the nanoscale of the structure and characteristics of materials (otherwise known as characterization) will promote the development of new applications and new products to repair or improve the properties of construction materials. For example, the structure of the fundamental calciumsilicate-hydrate (C-S-H) gel which is responsible for the mechanical and physical properties of cement pastes, including shrinkage, creep, porosity, permeability and elasticity, can be modified to obtain better durability. It is these "nano-effects", however, that ultimately determine all the properties that we are familiar with at our "macro-scale" and this is where the power of nanotechnology comes in. If we can manipulate elements at the nanoscale we can affect the macro-properties and produce significantly new materials and processes. Types of nano materials: i) Titanium dioxide (TiO2) ii) carbon nanotubes (CNT's) iii) nano silica(ns) iv) polycarboxilates v) nano Zro2,etc

II. APPLICATION OF NANOTECHNOLOGY IN BUILDING CONSTRUCTION INDUSTRY

- **APPLICATION IN CONCRETE**

Addition of nanoscale materials into cement could improve its performance. Use of nano-SiO2 could significantly increase the compressive for concrete, containing large volume fly ash, at early age and improve pore size distribution by filling the pores between large fly ash and cement particles at nanoscale. The dispersion/slurry of amorphous nanosilica is used to improve segregation resistance for

self-compacting concrete. It has also been reported that adding small amount of carbonnanotube (1%) by weight could increase both compressive and flexural strength.Cracking is a major concern for many structures. University of Illinois Urbana-Champaign is working on healing polymers, which include a micro-encapsulated healing agent and a catalytic chemical trigger. When the micro-capsules are broken by a crack, the healing agent is released into the crack and contact with the catalyst. The polymerization happens and bond the crack faces. The self healing polymer could be especially applicable to fix the micro-cracking in bridge piers and columns. But it requires costly epoxy injection.

- **APPLICATION IN STEEL**

Steel is a major construction material. Its properties, such as strength, corrosion resistance, and weld ability, are very important for the design and construction. It is possible to develop new, low carbon, high performance steel (HPS). The new steel was developed with higher corrosion-resistance and weld ability by incorporating copper nano particles from at the steel grain boundaries.

- **COATING**

The coatings incorporating certain nano particles or nano layers have been developed for certain purpose. It is one of the major applications of nanotechnology in construction. For example, TiO2 is used to coat glazing because of its sterilizing and anti fouling properties. The TiO2 will break down and disintegrate organic dirt through powerful catalytic reaction. Furthermore, it is hydrophilic, which allow the water to spread evenly over the surface and wash away dirt previously broken down. Other special coatings also have been developed, such as anti-fraffiti, thermal control, energy sawing, anti reflection coating.

- **NANOSENSORS**

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 (10 -9m to 10-5m). These sensors could be embedded into the structure during the construction process. Smart aggregate, a low cost piezoceramic-based multi-functional device, has been applied to monitor early age concrete properties such as moisture, temperature, relative humidity and early age strength development. 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.

- **THERMAL INSULATION AND ADDITIVES**

Thermal insulation for buildings, the use of invisible nanosilver coating for windows to get transparent thermal insulation, in façade design by providing self-cleaning, anti-graffiti protection or high scratch and wear resistance in plastics through appropriate coatings and use of titanium dioxide nanoparticles as additives in the interior coatings to protect from discoloration under interior and external light. Nanomaterials are used for self-healing concrete, flexible solar panels, as a paint for blocking wi-fi, ultraviolet and infrared radiation, smog-eating coatings, light-emitting walls and ceilings, nanodyes, nanoadditives for paints, silver nanoparticles or light activated nanoparticles as antibacterial household items, nanoparticles or nanoclays as fire retardant, surface nanostructures to give easy clean surfaces, water treatment systems and nanopigments for giving UV stability of polymers. Nanotech-enabled sensors can be used to monitor temperature, humidity, and airborne toxins which needs nanotech based improved batteries. The building components can be made intelligent and interactive by the use of sensor wireless components and collect a wide range of data.

- **SEISMIC WALLPAPER**

An intelligent composite "seismic wallpaper" has been developed for the reinforcement, strengthening, monitoring and management of civil infrastructure vulnerable to earthquakes. The composite seismic wallpaper consists of fiber-optic sensors, multiaxial, warpknitted glass and polymer fibers, nanoparticle-enhanced coatings for the textile fabric and nanoparticle-enhanced mortar to bond the textile to the structure. The specific nanoparticle-enhanced polymer coatings were produced to apply to a structure using a mortar compound. This mortar compound is also enhanced by nanoparticle polymer additives.

III. NANO-MATERIALS USED IN CONSTRUCTION

- **CARBON NANOTUBES** – Expected benefits are mechanical durability and crack prevention (in cement); enhanced mechanical and thermal properties (in ceramics); real-time structural health monitoring (NEMS/MEMS); and effective electron mediation (in solar cells).
- **SILICON DIOXIDE NANOPARTICLES** – Expected benefits are reinforcement in mechanical strength (in concrete); coolant, light transmission, and fire resistance (in ceramics); flame-proofing and anti-reflection (in windows).
- **TITANIUM DIOXIDE NANOPARTICLES** – Expected benefits are rapid hydration, increased degree of hydration, and self-cleaning (in concrete); superhydrophilicity, anti-fogging, and fouling-resistance (in windows); non-utility electricity generation (in solar cells).
- **IRON OXIDE NANOPARTICLES** – Expected benefits are increased compressive strength and abrasion-resistant in concrete.
- **COPPER NANOPARTICLES** – Expected benefits are weldability, corrosion resistance, and formability in steel.

- **SILVER NANOPARTICLES** – Expected benefits are biocidal activity in coatings and paints.
- **QUANTUM DOTS** – Expected benefits are effective electron mediation in solar cells.

IV. RISKS RELATED TO NANOTECHNOLOGY

Nanoparticles may also enter the human body of if building when water supplies are filtered through commercially available nanofilters. Airborne and waterborne nanoparticles can enter from building ventilation and wastewater systems. Use of sensors can create loss of privacy when users are made to interact with increasingly intelligent building components and can infuse a fear of risk from these materials. However, the major opinion is that overall performance of nanomaterials is a valuable opportunity to improve building performance, user health and environmental quality. But, once discarded, these materials become potent source of uncontrollable particles, which may pose a health risk to the population living close to the area where they were dumped, but there are also methods to recycle or reuse rather than thrown away.

V. CONCLUSION

Nanotechnology is disruptive and offers the possibility of great advances whereas conventional approaches, at best, offer only incremental improvements. Nanotechnology is not exactly a new technology, rather it is an extrapolation of current ones to a new scale and at that scale the conventional tools and rules no longer apply. Nanotechnology is therefore the opposite of the traditional top-down process of construction, or indeed any production technique, and it offers the ability to work from the "bottom" of materials design to the "top" of the built environment. However, many of the advances offered by nanotechnology, be they for economic (carbon nanotubes cost 20-1000€/gram) or technical reasons, are years away from practical application, especially in the conservative and fragmented construction business.

At this moment the main limitation is the high costs of nanotechnology. Also concerns with the environmental and health effect

There are three main issues that might prevent the widespread use of the nanotechnology:
(1) Lack of vision to identify those aspects that could be changed through its use.
(2) Lack of skilled personnel.
(3) Level of investment.

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