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Nano Technology in Construction

Dr. A.S. Kanagalakshmi., Professor M.C.Arivukarasi., C.M.Keerthana ,
R. Subashri, V.Vishnu Priya.
Corresponding Author: Dr. A.S. Kanagalakshmi

Abstract: *Nanotechnology is one of the most active research areas that encompass a number of disciplines, including civil engineering and construction materials. The Nano-materials and their applications in civil engineering field across its different sections are exemplified. The properties like self-sensing, self-rehabilitation, self-structural health monitoring, self-vibration damping, self-cleaning and self-healing are studied. The objective of this study is to review the role of nanotechnology in civil engineering applications. Furthermore, it has been observed that better understanding and engineering of complex structures made by cement, steel or composite materials at nano-level will definitely result in a new generation of construction materials with higher performance in strength, durability, and other properties.*
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I. Introduction

Nano, which comes from the Greek word for dwarf, indicates a billionth. One nanometre is a billionth of a metre. Definitions of 'nanotechnology' vary, but it generally refers to understanding and manipulation of matter on the Nano scale, say, from 0.1 nm to 100 nm.

Nano technology has several applications in the engineering field, especially in the area of civil engineering. A enormous number of materials can be enhanced by the use of nanotechnology, some of which include glass, concrete, and steel. Nanoparticles can also be used in coatings such as paints to give the coating "self healing capabilities and corrosion protection under insulation. As a child we use to design and make buildings out of paper, and the idea of the design and construction of buildings has always been of interest to me. As a future engineer we would like to be able to do research on finding new materials to help create stronger, better, longer lasting buildings and structures. Nanotechnology can, and has revolutionized the way civil engineering is conducted by opening new possibilities for materials and is an important aspect to the field of civil engineering.

USES OF NANOTECHNOLOGY IN CIVIL INFRASTRUCTURE

Nanotechnology can be used for plan and construction processes in many areas ever since nanotechnology generates products have many only one of its kind characteristics. These characteristics can, again, considerably fix present creation tribulations, and may adjust the requirement and associations of construction process.Some of their applications are examine in detail below.

APPLICATION OF NANOTECHNOLOGY IN CONSTRUCTIONS

Many disciplines of civil engineering, including design and construction processes can be benefited from nanotechnology. These include products that are for: Lighter structure, Stronger structural composites, e.g. for bridges and others. Low maintenance coating, Improved pipe joining materials and techniques, Better properties of cementitious materials, Reduced thermal transfer rate of fire retardant and insulation, Increased sound absorption of acoustic absorber, Increased reflectivity of glass, water repellents, nano-clay filled polymers, self-disinfecting surfaces, UV light protector, air cleaners, nano-sized sensors, and solar cells.
There are a large number of applications of nanotechnology in the construction engineering/industry. Some of these applications are examined in detail below.

NANO-CEMENT

Portland cement is the most widely used construction material. It can be argued that concrete utilizes nanotechnology because it contains nano-particles as its ingredients, including nano-water particles and nano-air voids.

Concrete is a macro-material, strongly influenced by its nano-properties and understanding it at nano level can provide the avenues for improvement of strength and durability. The particle size of cement can be reduced to nano-size or can be modified by adding nano-tubes and reactive nano-size silica particles.

CARBON NANOTUBES

Carbon nanotubes are over 100 times stronger than steel and only one-sixth of the weight in addition to its high thermal and electrical conductivities. A CNT composite has recently been reported to be six times stronger than conventional carbon fibre composites. Additionally, unlike carbon fibres which fracture easily under compression, the nanotubes are much more flexible and can be compressed without fracturing. CNT composite reinforced structures have a 50 to 150-fold increase in tensile strength, compared with conventional steel-reinforced structures.

NANO-COMPOSITES

Nano-composites can be developed by using nano-tubes, which can implant some of the outstanding properties of the nano-tubes. Alumino-silicates are mixed with carbon nano-tubes, which can produce strong and durable conductive films. Furthermore, the current sizes of alumino-silicates (50 to 100 nm) can further be reduced to 5 to 10 nm range, and a little volume percent of nano-tubes (≈ 0.5%) can produce extraordinary composites. Besides, fibre wrapping that has been commonly used to strengthen the existing concrete structures has witnessed advancement by using fibre sheet (matrix) containing nano-silica particles and hardeners . These nano-particles 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.

Mineral and Metal Nano-materials to Improve Resistance to Biological Agents and Fire

A part from the structural change caused by heat-treatment, fungicide property of some minerals at nano-scale can also improve the biological durability of wood and wood-composite materials. In this regard, wollastonite nano-fibers (NW) have been reported to substantially improve the durability in poplar wood .Nano-silver and NW have also been reported to significantly improve fire-retarding properties in solid woods and wood-composite materials.

The high thermal conductivity coefficients of NW materials have been reported to primarily transfer heat throughout the body of wood, preventing accumulation of heat over the surface layer, and eventually decrease the temperature below the ignitability of wood components. NW helps fire resistance in a second way by acting as an impermeable physical barrier towards flame. NW forms a fire barrier towards the penetration of flames into the body of wood structure.

NANO-COATINGS FOR CONCRETE

The coatings incorporate certain Nano particles or Nano layers have been developed for certain purpose including: protective or anti-corrosion coatings for components; self- cleaning, thermal control, energy saving, anti-reflection coatings for glass/windows; easy-to- clean, antibacterial coatings for work surfaces; and more durable paints and anti-graffiti coating for buildings and structures. For example: Self-cleaning windows have been developed and marketed by Pilkington, St. Gobain Co., and others. This coating works in 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. Coating of 7000 m2 of road surface with such a material in Milan in 2002 has led to a 60% reduction in nitrogen oxides concentration at street level. Research has also demonstrated that bimetallic Nano particles, such as Fe/Pd, Fe/Ag, or Zn/Pd, can serve as potent reductants and catalysts for a large variety of environmental contaminants. The product offers 20 times more water-repellent property than a smooth, wax coating. Special coatings can also make the applied surface both hydrophobic and oleophobic at the same time.

GLASS

Fire-protective glass is another application of nanotechnology. This is achieved by using a clear intumescent layer sandwiched between glass panels (an interlayer) formed of fumed silica (SiO2) nanoparticles which turns into a rigid and opaque fire shield when heated. The electrochromic coatings are being developed that react to changes in applied voltage by using a tungsten oxide layer; thereby becoming more opaque at the touch of a button.

Because of the hydrophobic properties of TiO2, it can be applied in antifogging coatings or in self-cleaning windows . Nano-TiO2 coatings can also be applied to building exteriors to prevent sticking of pollutants, and thus reduce a facility’s maintenance costs.

The use of coatings made from nanotechnology helps get better fire-resistance, corrosion protection, insulation, and innumerable other applications.

NANO-STEEL

Steel has played a major role in the construction industry since past two centuries. Fatigue is a significant issue for the structures subjected to cyclic loading, such as in bridges, towers, and off-shore platforms. Fatigue failure can occur at significantly low stresses than the yield stress of the material and lead to a significant reduction in service life.

Stress concentration is responsible for initiating cracks which triggers fatigue failure, and research has shown that the addition of copper nano-particles reduces the surface unevenness of steel, which then limits the number of stress risers, and hence fatigue cracking. Furthermore, it has been reported that vanadium and molybdenum nano-particles can improve the fracture problems associated with high strength bolts.

NANO-PARTICLES FOR FIRE PROTECTION

The application of Portland cement based coatings for fire protection of steel structures is limited since it is thick, tends to be brittle, and polymer additions are needed to improve adhesion with steel surface. It has been found that nano-cement mixing with carbon nano- tubes (CNT) with cementious material to fabricate fibre composites has outstanding properties of high strength and fire resistance.

CLAY/POLYMER NANO-COMPOSITES

One of the most interesting interdisciplinary areas in civil engineering discipline is clay/polymer composites. This technology has received great attention in the area of nano- composites research. It offers tremendous improvement in a wide range of physical and engineering properties for polymers with lower percentage of filler.

This nano-composite approach has advantages over the so called fiber reinforced composites in the low filler loading range. The basic phenomenon behind this technique is “bottom-up and top-down approaches”. In the bottom-up approach, the nano-materials are made from atoms or molecules (small to big) and by adopting this principle, molecules can be made to arrange themselves automatically into useful shapes and structures.

Clay/polymer nano-composites have improved physical and engineering properties, including fire retardancy, barrier resistance, and ion conductivity (Hutchison et al. 1996). This polymer composite technique can also be useful for water-soluble hydrophilic/hydrophobic functional monomer systems for the preparation of polymer/silicate hybrid nano-materials.

COST

The costs of most nanotechnology materials and equipment are relatively high. This is due to the novelty of the technology and the complexity of the equipment used for preparation and characterization of the materials. However, costs have been shown to decrease over time and the expectations are that, as manufacturing technologies improve, these costs may further decrease. Whether the expected decrease will render the materials as run-of-the- mill construction engineering materials will have to be seen, and depends largely on the benefits rendered through the application of these materials. Current opinion is that in special cases, the materials will enable unique solutions to complicated problems that cause them to be cost effective, which will lead to large scale application of these specific technologies. In other cases, the traditional methods for treating the problem may still remain the most cost effective. It is a challenge to the construction engineer to solve real world transportation infrastructure problems and provide a facility to the general public at a reasonable cost.

II. Conclusion

Nanotechnology offer infinite amounts of improvement in the civil engineering field. The use of nanotechnology has also helped formed more efficient also sustainable materials such as self- cleaning and self-repairing concrete and window. Nanotechnology can even help improve the quality and availability of water. Nanotechnology is important to the future and improvement of civil engineering; on the other hand it cannot contribute to the field if it is not skilled on a wider level as well as to every aspiring civil engineer. Based on the short review in this paper, nanotechnology has the potential to be the key to a brand new world in the field of construction and building materials. Furthermore, nanotechnology is a rapidly expanding area of research where properties of materials manufactured on nano-scale can be utilized for the benefit of construction infrastructure, and a number of promising developments exist that can potentially change the service life and life-cycle cost of construction infrastructure to make a new world in the future.

References

[1]. M. O. Zakir, B.S. Rzayev, and E.A. Soylemez, Functional Copolymer/Organo-MMT Nanoarchitectures. VIII. Synthesis, Morphology and Thermal Behavior of Poly (maleic anhydride-altacrylamide) - Organo-MMT Clays Nanohybrids, Scientific Research, Engineering (2011)

[2]. F. Pacheco and S. Jalali, Nanotechnology: Advantages and drawbacks in the field of construction and building materials, Journal of construction and Building Materials (2011)

[3]. sanchez, florence, and konstantin sobolev. "Nanotechnology in concrete--a review." construction and building materials nov. 2010: 2060+. General onefile. Web. 9 oct. 2012.

[4]. "list of nanotechnology applications." Wikipedia. Wikimedia foundation, 30 sept. 2012. web. 09 oct. 2012. <http://en.wiki pedia.org/wiki/list_of_nanotechnology_appl ications>.

[5]. "nanotechnology doubling the service life of concrete." nanotechnology doubling the service life of concrete. n.p., jan. 2009. web. 09 oct. 2012. <http://www.azonano.com/ news.aspx?newsid=9604>.

[6]. mohan, prem. "civil engineering seminar topics: significance of nanotechnology in construction engineering." civil engineering seminar topics: significance of nanotechnology in construction engineering. n.p., 17 sept. 2011. web. 09 oct. 2012. <http://civilenggseminar.blogspot.com/2011 /09/significance-of-nanotechnology- in.html>.

[7]. "code of ethics." american society of civil engineers. n.p., n.d. web. 29 oct. 2012. <http://www.asce.org/leadership-and-management/ethics/code-of-ethics/>.

[8]. "nspe code of ethics for engineers." nspe code of ethics for engineers. National society of professional engineers, n.d. web. 30 oct. 2012. <http://www.nspe.org/ethics/ codeofethics/index.html>.

[9]. Z.D. Bolashikov and A.K. Melikov Methods for air cleaning and protection of building occupants from airborne pathogens, Building and Environment (2009); Vol.44, no.7, p.1378–85.

[10]. G. Reboux, A.P. Bellanger, S. Roussel, F. Grenouillet and L. Millon, Moulds in dwellings: health risks and involved species, Revue des Maladies Respiratoires (2010), Vol.27, no.2, p.169–79.

[11]. M. C. Roco, R. S. Williams, and P. Alivisatos, Nanotechnology Research Directions: IWGN Research Report, Committee on Technology, Interagency Working Group on Nanoscience, Engineering and Technology (IWGN), National Science and Technology Council, (1999).

[12]. K.P Chong, Nanoscience and Engineering in Mechanics and Materials, Journal of Physics & Chemistry of Solids (2004), Vol.65, p.1501-1506.

[13]. K.P Chong, Research and Challenges in Nanomechanics, 90- minute Nanotechnology Webcast, ASME, archived in www.asme.org/nanowebcast, (2002).

[14]. K. Drexler, Molecular engineering: an approach to the development of general capabilities for molecular manipulation, Proc Natl Acad Sci USA (1981), Vol.78, pp.5275–5278.

[15]. M.C. Roco and W.S. Bainbridge, Societal implications of nanoscience and nanotechnology: Maximizing human benefit, Journal of Nanoparticle Research (2005), Vol.7, no.1, p. 1-13.

[16]. W. Zhu, P.J.M. Bartos and A. Porro, Application of nanotechnology in construction, Summary of a state-of-the-art report, Journal of Material and Structures (2004), Vol.37, p.649–58.

[17]. N. Jennet, G. Pharr and C. McHargue, An experimental evaluation of the constant B relating the contact stiffness to the contact area in nanoindentation, Philosophical Magazine, Special Issue: Instrumented Nanoindentation (2006), Vol.86, p.5285-5298.

[18]. B. Bhushan, T. Kasai, G. Kulik, L. Barbieri and P. Hoffman, AFM study of perfluoroalkylsilane and alkylsilane self-assembled monolayers for anti-stiction in MEMS/NEMS, Journal of Ultramicroscopy (2005), Vol.105, p. 176-188

[19]. L. Lu, R. Schwaiger, Z.W. Shan, M. Dao, K. Lu and S. Suresh. Nano-sized twins induce high rate sensitivity of flow stress in pure copper, Acta Materialia (2005), Vol.53, no.7, p.2169-2179.

[20]. S. Suresh and A.E. Giannakopoulos, A new method for estimating residual stresses by instrumented sharp indentation, Acta Materialia (1998), Vol.46, no.19, p.5755-5767.

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