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## Nanotechnology and building industry

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### Abstract

Nanotechnology is one of the new technologies and the demand for new materials in the building industry has been increased with increase in the population and constructions as well as the deficiency of consumable resources and materials. Attempts for achieving solutions to improve the quality and increase material function and reduce the consumption of raw materials and energy have led to use new technologies in this industry. Nanotechnology is one of the greatest new technologies in the present century, which has Valuable applications in the building industry. Among the cases of using nanotechnology in the building industry, the production of appropriate materials with proper characteristics for various parts of a building, the use of them in the building facilities as well as its application in production, consumption, and saving energy with high performance could be mentioned.

**Key Words:** Nano, Nanotechnology, Material, Building construction.

### Introduction

The realization of global and national policies provides major opportunities for revision of the use of land, energy, and environment so that it could be created a habitation that not only provides a desirable and high quality life for the present and future generations, but also ensures the sustainability of the Earth planet and the human spirit (Taghadosi, 2002). Nowadays, the application of new technologies in various industries has led to the incidence of great developments in the process of completion and upgrading of technology and human knowledge. Nanotechnology, as one of the new human technologies has been able to make substantial developments in various industries especially the construction industry. The substance of nanotechnology is the ability of working in the atomic and molecular scales, and beyond that, in the dimensions of 1 to 100 nm with the aim to produce and manipulate in the how atoms or molecules are arranged, by the use of material, equipment, and systems with new capabilities. In fact, the purpose is to create future molecule by molecule. The nanotechnology will lead to make dramatic changes in the use of natural resources,

energy, and water and reduces wastewater and pollution. In addition, it will provide the possibility of recycling and reuse of materials, energy, and water. Regarding the indiscriminate use of energy and the environmental damages, the world energy is in a critical condition, which looking for a solution in this field will be a help for survival and preservation of the environment for future generations (Abbaspour 2007).

Regarding the fact that materials constitute the core of building construction, nanotechnology could guide the world engineering community to a new industrial revolution. Nanotechnology consists of the combination of very fine particles to create new materials. Research and development in the field of nanotechnology are including a conscious and controlled employing of nanoscale structures and incorporate them into the combination, system, and the architecture of larger components of the material. Inside this collection will be in larger scale and the establishment of their structures and components will be retained in the nanometer scale. In some special cases, the fundamental dimensions that create these new features and phenomena, could be below 1 nm or larger than 100 nm. Any research work performed in a scale under 100 nm, or in other words at least has one dimension (length, width, or thickness) under 100 nm, is so-called nanotechnology (Golabchi, 2011). The improvement of physical and mechanical specifications of building materials using nanotechnology has produced great advances in the building industry and has given designer and engineers the possibility of make sustainable buildings and in harmony with nature and the environment. The main specifications of nanomaterials are related to the size of fundamental particles. The surface area to volume ratio of nanomaterials is the most determining principle in nanotechnology and nanomaterial science. Nanotechnology could be used for design and construction processes in many materials, because the productions of nanotechnology are of distinct specifications that could be useful in the strengthening of materials. Nanotechnology plays a remarkable role in the building industries and in this consideration, steel, concrete and glass have the most contribution (Golabchi, 2011).

With the application of nanotechnology and its integration with other specialties, there have been obtained many achievements, which less production and maintenance costs, lower energy consumption, and longer life time could be mentioned among them (Zhu, 2004). From long ago, various pollutions were being a serious threat for global environment and human life. In century twenty-one, the development of new technologies that flourishes the industrial economy without damaging the human health and the environment, is of a significant importance. The development of new technologies of construction and transmission and the other activities for reducing or eliminating harmful products during production, and the purification and modification of toxins in the environment is the most important current challenge of our communities. In the field of energy, the nanotechnology could considerably influence the efficiency, energy saving and its production and reduce the energy consumption. With regards to the major changes that will be occurred in the 10 future years in nanotechnology, it could produce considerable energy in nano dimensions (Serrano, 2009).

#### **Research Method**

The implementation of a descriptive research could be just to learn more about the existing conditions or to help the decision-making process and to answer this kind of research question. For example, what kind of relationship is there between events (Sarmad et al., 2010). In the present study, in order to determine the type of nanotechnology applications in architecture and building industry, different aspects of nanotechnology and its effect on building industry have been investigated by referring to the reference and library as well as the use of analytical and descriptive methods.

#### **1-1- Nano and Nanotechnology**

Although the term nano is a new phrase, nanotechnology in the industry is much more entrenched than our thought. It is more than 1000 years that carbon nanoparticles are used for reinforcing tires. Protein nanoparticles constitute a major part of vaccination since the beginning of the twentieth century to the present day. The process of photosynthesis of plants is done for millions of years. Ruby red color glasses that was famous in medieval and had many decorative uses, were because of gold nanoparticles, which were caught in the glass matrix (Sharifi, 2011). The nanotechnology is the ability of producing material, tool, and new systems with taking control in molecular and atomic level and is the use of some features that are appeared in these levels. It could be found from this simple description that nanotechnology is not a new field, but a new approach in all fields (Mahmoudi, 2008). In fact,

nanotechnology is the implementation of the intended molecular structure with atomic precise. Since all the material productions are created from placing atoms together with special arrangement, the nanotechnology potentially provides the possibility of producing the productions required by human (Nanotechnology, 2002). "Nanoparticles" in the nanotechnology deals with the composition and bond of the so-called particles and their application. In general, the nanomaterial production is called if the particle sizes of study range between 1 to 111 (Golabchi, 2011).

#### **2-1- Nanotechnology Applications in the Architecture**

The use of nanotechnology in the architecture is very extensive form the primary steps of design and simple sketches to the final steps and physical touch of joineries. The application could be observed especially in the proper selection of materials that is done so that not only be a reflection of the design ideas and imaginings, but also influence the way of thinking of the architect. This variety in the selection is by the help of a wide range of options that nanotechnology has opened for designers. Therefore, material and design are the first paths, in which nanotechnology could be the cause of influence (Golabchi, 2011). The nano application in architecture includes a wide range of material and equipment, which its purpose is the materialization and implementation of theories (Golabchi, 2011). Nanotechnology make us a step closer to have materials that are of favorable properties. Dispensing with the restraints of existing traditional materials, it could be defined different and clear performances for new nano production materials, which are substantially different with the nature and properties of their primary materials (Golabchi, 2011).

The incorporation of nanotechnology in the building industry makes expectations in terms of essential improvement of the characteristics and qualities of building materials (strength, durability, lightness, etc.) in the mind of specialists of this field (Golabchi et al., 1982). Because the common technical properties of materials such as failure strength, elastic modulus, electrical and thermal conductivity, and other specifications depend on their mechanical, thermal, optical, and chemical characteristics. Specifically, these properties have the main importance for the use of materials in the building or other productions, from the viewpoint of engineering and it is expected that employing nanotechnology would lead to dramatic improvements and advances in these properties of materials (Golabchi, 2011). Additionally, new performances (energy saving, self-repairing, anti-fog capability, etc.) and the improvement and enhancement of main components that are used

with the aim to maintenance the health insurance of the building, could be anticipated from the new materials.

## **2-2- Nanotechnology in Building**

It is not a long time passed from the entrance of the emerging nanotechnology into building engineering. The first researches in the field of the applications of nanotechnology in building industry returns to 1990s. Since that time, the nanotechnology has been increasingly developed in architecture and building engineering. Better and more powerful insulation, self-cleaning glasses, nano covers, nano-based colors and adhesives and other materials of this type, in addition to have multi performances are of many advantage and more practical properties (Rana et al., 2009). Year 1985 was the usher of the emergence of nanotechnology in architecture, when the great architect, Richard Buckminster Fuller, with three other scientists introduced the spherical atoms of carbon in the dimensions of 1 nm (a millionth of a meter) to the world. Since then, these atoms have been named buckyball in his honor (Tourgal and Jalali, 2010). The buckyballs could be imagined similar to traditional black and white soccer ball. Carbon nanotubes (CNTs) are today's shining stars in the vast shores of nanotechnology, which are briefly called nanotubes. The most important help of nanotechnology in the field of building material could be considered as their contribution to less raw material and energy consumption. In terms of economic and environmental viewpoints, the human use of nanotechnology could be his trump card in long time. Better understanding and the development of nanostructures, has changed the traditional methods of production as well as the uses of building materials. Consequently, the new aspects of building materials has also make major changes in the type of using material as well as the loads exerted on them, calculating their needed strength in design, and other aspects corresponded to construction and building management (Golabchi et al., 2011).

Better understanding and the development of nanostructures, world development of traditional production and application, the building industry is in the eighth position (Bitner and Bartous, 2009). As regards to being a new technology, various applications of it will be introduced in different industries, with the passage of time. In this section, the applications of nanotechnology in the building industry are mentioned, briefly.

### **2-2-1- Nano covers**

Nano covers are one of the practical branches of nanotechnology in different industries. From nano covers used in the building industry, the covers of stone, wood, brick, ceramic, tile, and coverages of concrete surfaces could be mentioned. The

nanostructure covers are of many advantages than conventional covers in many cases including increase in stiffness, resistance against corrosion, abrasion, rottenness and environmental pollutions, etc. (Gholami, 2012).

### **2-2-2- Improvement of cement and concrete properties**

The use of nanoparticles leads to improve the mechanical specifications and increase the cement and concrete quality. Moreover, nanoparticles and nano covers prevent the penetration of external damaging factors into concrete, which might lead to reduce durability and stability and to increase the damage rate of concrete. Nanoparticles could be used in concrete, adding these nanomaterials to self-compacting concrete and nanosilica high performance concrete cause the particles to be compacted with more efficiency, increases the concrete strength and prevents water penetration into the concrete. The use of titania ( $\text{TiO}_2$ ) leads to create self-cleaning and disinfection property in the concrete and makes the concrete white color and shining. CNTs are other additives of concrete that despite that have a density about one-sixth of steel, their Young modulus and strength are 5 and 8 times more than steel, respectively. This nano additive could be used as an appropriate reinforcing with the capability of reducing the dimension and deformation of cracks. Hematite 9 nanoparticles are also a cause for increasing concrete strength (Jan Bozorgi, 2010).

### **2-2-3- Nano glasses**

From the applications of nanotechnology in the industry of glass productions, some products such as self-cleaning glasses, energy-controlling glasses, and fire-protecting glasses could be mentioned. In the production of self-cleaning glasses, titania ( $\text{TiO}_2$ ) nanoparticles are used. These glasses have the property of being anti-smudge and disinfection. Fire-protecting glasses are produced through placing a transparent layer containing silica nanoparticles between two glass layers. The energy-controlling glasses lead to reduce ultra violet and infrared wave's transmission, tuning visible light transmission and also avoid wasting energy inside the building (Jan Bozorgi, 2010).

### **2-2-4- Nanotechnology and Steel**

Steel is one of the important metal in the construction industry. Researches have shown that adding copper nanoparticles to steel reduces the steel surface roughness resulting in limiting the number of factors that increase stress and also limits the cracking caused by structural fatigue in bridges and towers, in which loading is done cyclically (Balikhani, 2009).

### **3-1- The Role of Nanotechnology in the Environment**

The rapid development of science and technology, particularly in the field of nanotechnology have caused to make great changes in industry, the environment, and Basic biological sciences, in the recent years. The elimination of pollutants, retrofitting polluted soils, purification of surface and underground waters, removing microorganisms, reducing water turbidity and hardness, and salt excretion and water desalination are form the usefulness of using nanotechnology. Generally, by making efficient the devices and tools used in various fields and by reducing the raw material and energy consumption, nanotechnology has provided the possibility of performing effective operations in the direction of protection of natural resources and the environment. In the field of energy, nanotechnology could significantly affect the efficiency, energy saving and production and reduce the energy consumption. However, the other aspect of this capability is the probable risks of using nanotechnology productions, which is due to the failure to comply with certain rules and regulations. In addition, nanotechnology makes the existing productions more effective and more efficient, the size of these particles that is of the main properties of them, threats the health and environment. The manufacturers of nano products believe that these productions are less dangerous than other productions, environmentally; however, more researches are required to be conducted on these productions (Nama professional monthly magazine, 2012).

Researchers have considered six main pillars of nanotechnology to help solving environmental problems and challenges in construction industry. According to this categorization, building industry benefits from six groups of nano-based materials: nano-based materials (volumetric), nano-based surfaces (two-dimensional), nano optic material; nano sensors and nano electric materials; produce, save and storage energy; environmental purification and cleanup with nano-based approach (golabchi, 2011).

### **4-1- Nanotechnology and Building**

The past times use of traditional material that not only have not a suitable durability and stability compared with new materials, but often were single functional and they could not be used multipurpose. Moreover, due to low modulus and strength, a large amount of them must have been used in the building (Farrelly, 2009). Nanotechnology is able to have a direct effect on some cases including composite structural material with less weight and higher strength, covers needed lees preservation, rising quality of methods and materials of pipe connections, descend the heat

transfer coefficient of insulation and incendiary materials, increase the quality of absorb sound waves for sound-absorbing materials, increase the glass reflection power, producing powerful concretes and nano sensors.

The pervasive influences of nanotechnology in the human life and the form of his relation with surrounding area and buildings, is inevitable. Construction time is currently long but it will be reduced over time. It is obvious that the nanotechnology achievements governs the future industries. Nanotechnology is promising new forms, new functions, and new connections between people, buildings, and the environment (Tourani, 1999).

Nanotechnology creates fundamental changes by changing the structure of human life and builds a strong connection between the human and the environment. Perhaps, some of these divinations are exaggerated about nanotechnology; however, its final purpose is the detailed production of materials with various specifications. Nano has been defined at any period of time and with the emerge of this technology, it is obtaining a new definition and the spatial geometry in the form of molecules and atoms provides the building stability. Actually, this is not a sci-fi dream, because the nano science will occurred much sooner than a reality (Smsley, 1995). About current condition and the future potential of nanotechnology in building, it has been regarded as the most important reasons for the incomplete development of nanotechnology and nanomaterials in the construction industry, of which the prevalent reluctance and very limited involvement of building companies in the field of nano researches and also the lack of in order to transfer this technology could be noted (Mann, 2006). High cost, the low number of scientific and non-experimental methods for the crystallization of nano ideas in the building, fragmentation and being less research-based of this industry, and the traditional conservative approaches are of the major obstacles to the development of new technologies. Of course, the low level of general knowledge of construction industry contributors and their negative attitude towards this technology should not be overlooked (Bartos, 2003).

The use of technology in construction in addition to prevent wasting various resources in different fields and also the optimum use of energy, could help to increase the useful life of buildings and retrofit it against sound, humidity, temperature, earthquake, and other natural disasters (economically). In addition, employing nano products in construction industry will lead to reduce energy consumption and labors during the construction and operation of buildings and will

provide desirable spaces for their residents by the elimination of pollution in indoor and outdoor spaces and providing comfort conditions. By providing recycling and reuse of materials after completing building lifetime or recycling the materials used in it, nanotechnology will reduce environmental damages as much as possible (Seifaldini et al., 2012).

In the case of the cost of nanomaterials, it could be said that their production cost is high and because cost is one of the most determining parameters in the building industry and due to being associated the cost of using materials with their applications, certainly the production and application of these new generation of materials is limited. Nowadays, the cost of producing each gram of nano-based materials is at least around \$ 500 and can reach even up to several thousand dollars (Ashby, 2009).

With the development the production and use of nanomaterial in buildings, the damaging potential of it on the environment and human health should not be ignored. In this regards, one of the critical and basic steps in specifying the risk of using these new productions and reducing and preventing their damaging impacts, is performing a comprehensive evaluation in this field. In this step that no accurate reports are recorded about the toxicity and being harmful these nanomaterials to human health and living organisms, the most prudent way to prevent potential risks, is avoiding direct contact with these materials, which regardless their probable toxicity of them, if no contact is made with these materials, the possibility of transmitting harmful toxins or pathogens would not be existed. (Golabchi et al. 2011).

### **Conclusion**

For summarizing the application of nanotechnology in construction industry, it could be expressed so that this technology is attempting to penetrate the building industry from two aspects: at first, in order to optimize and enhance the performance of existing technologies, and then, to present a new group of materials and productions that had not been possible before the emerge of nanotechnology. Originally, the nano science and technology has put a new path in front of building engineers, from which new methods have been shown to produce high efficiency materials with better performances. More durable and higher quality concretes and more strength steel and self-cleaning glasses could be produced, thanks to this technology. Finally, it could be noticed that recent advances in the science have led to create materials by nanotechnology, and therefore, the reaction of materials in the nanotechnology could be controlled and fit it in the direction of building engineers performance.

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