European Journal of Sustainable Development (2015), 4, 1, 161-166 ISSN: 2239-5938
Doi: 10.14207/ejsd.2015.v4n1p161

Importance of Nanotechnology in Civil Engineering

By Kaizar Hossain[1*] & Shaik Rameeja[2]

ABSTRACT
Nanotechnology is an extremely wide term, the definition of which varies from field to field. Most commonly, nanotechnology is defined as "…the understanding, control, and restructuring of matter on the order of nanometers (i.e., less than 100 nm) to create materials with fundamentally new properties and functions" [1]. Nanotechnology refers to the manipulation of individual atoms and molecules, by engineering matter at the atomic level. At the nanoscale, familiar materials can have dramatically different properties: changes can affect color, elasticity, strength, conductivity, and other properties. Nanoparticles also have an increased surface area relative to their volume, making them especially reactive and useful in energy storage, for making composite materials, or as drug delivery devices. Nano materials are also able to be integrated with biological materials, producing new structures that have properties of both types of materials. There are two main types of approaches to nanotechnology: The "top-down" approach and the "bottom-up" approach. The "top-down" approach involves taking larger structures that are either reduced down in size until they reach the nano-scale, or are deconstructed into their composite parts. On the other hand, the "bottom-up" approach is where materials are constructed from the atomic or molecular components.

Key Words: materials, structures, nanoparticles, Titanium dioxide,

1. Introduction:

Nanotechnology in Civil Engineering
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. Since these coatings are hydrophobic and repel water from the metal pipe and can also protect metal from salt water attack." [2].

The amalgamation of nanotechnology in civil engineering and construction is immensely useful to the field. Nanotechnology can be used to increase the life of concrete, create fire-resistant materials such as steel, and give building materials qualities such as "self-healing" and "self-cleaning." On a personal level, we are very interested in the design,

[1]HOD- Civil Engineering- PACE Institute of Technology and Sciences, Ongole- India.
[2]Research Scholar, Environmental Sciences, Andhra University, Visakhapatnam- India.
* Corresponding Author

construction, and engineering of buildings and other infrastructure. 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. It is for this reason that we believe that nanotechnology should be more widely incorporated into engineering curriculums around the country. Currently, only a few colleges and Universities teach nanotechnology within their engineering programs, or even offer a degree in nanotechnology. This needs to be changed, especially for the field of civil engineering as nanotechnology is vital to the advancement of the field.

2. Application of Nanotechnology in Concrete

The most frequent and beneficial uses of nanotechnology in terms of civil engineering, is the use of it in concrete. Concrete "is a nanostructured, multi-phase, composite material that ages over time. It is composed of an amorphous phase, nanometer to micrometer size crystals, and bound water," [1]. It is used in almost all construction, from roads, to bridges, to buildings. Concrete can be modified in numerous ways; one of which is to add nanoparticles to it. Most research done with nanoparticles is done with nano-silica, nano-titanium oxide, and some studies involving nano-iron, nano-alumina and nanoclay. These "nanoparticles can act as nuclei for cement phases, further promoting cement hydration due to their high reactivity, as nanoreinforcement, and as filler, densifying the microstructure and the ITZ, thereby, leading to a reduced porosity," [1]. Each of the nanoparticles has a different on concrete. Nano-silica improves strength, resistance to water penetration, and helps control calcium leaching. Nano-titanium has been proven to assist in the "…self-cleaning of concrete and provides the additional benefit of helping to clean the environment," [1]. Nano-iron has shown to give concrete self-sensing capabilities and improved it's "…compressive and flexible strengths," [1]. Other areas of research pertaining to nanotechnology in cement include hydrate hybridization, (which is the creation of "hybrid, organic, cementitious nanocomposites,"), as well as the use of nanoreinforments, (carbon nanotubes and nanofibers).

The example of how nanotechnology improved this vital construction material is when the engineers at the National Institute of Standards and Technology patented a method to increase the lifespan of concrete in 2009. In 2007, almost one quarter of all bridges in the country were defective or obsolete all together. The reasoning for this was the Chloride and sulfate ions would infiltrate the concrete and cause internal structural damage, weakening the concrete and causing cracks. The engineers at the NIST wanted to "…change the viscosity of the solution in the concrete at the microscale to reduce the speed at which chlorides and sulfates enter the concrete," [3] in a project called "…viscosity enhancers reducing diffusion in concrete technology (VERDICT)" [3] in order to attempt to double the lifespan of concrete.

3. Nanotechnology In Steel

Steel is one of the most important building materials used today. The major problems of using steel however, is dealing with fatigue. "exhaustion is one of the significant issues that can lead to the structural failure of steel subject to cyclic loading," [4]. Fatigue can occur at stresses that are lower than the yield stress of the steel and leads to a shortening of the steel's life. The best way to reduce the fatigue is to add copper nanoparticles to the steel. The copper nanoparticles can help reduce the unevenness in the surface of the steel, which in turn reduces the amount of stress risers. Since the steel now has less stress risers, fatigue cracking is limited as well. "The new steel can also be developed with higher corrosion-resistance and weld ability," [4]. Another steel-related issue that is resolved by nanotechnology is in the area of welding. Welding strength is an extremely important issue. The area affected by heat in a weld can be brittle and fail without warning at times. The addition of nanoparticles such as magnesium and calcium can help solve this issue by making "the heat affected zone grains finer in plate steel," [4] which leads to strong welds. Improved fire resistance can also be achieved through nanotechnology. This is frequently done through a coating however, where the coating is "produced by a spray-on-cementitious process," [2].

4. Nanotechnology In Glass, Wood, And Other Areas

Nanotechnology is used in many different materials, including wood and glass. Wood is made of nanotubes or nanofibrils, primarily "lignocellulosic (woody tissue) elements," [5] that are twice as strong as steel. Being able to use these nanofibrils would "...lead to a new paradigm in sustainable construction," [5] since the creation and use of the material would be a part of a renewable cycle. Using these lignocellulosic could open up the possibility of "self-sterilizing surfaces, internal self-repair and electronic lignocellulosic devices," [5].

Glass also makes use of nanotechnology. Nano-Titanium dioxide is used to coat glass can give the glass a self-cleaning property. Titanium dioxide breaks down organic wastes and compounds, and because it also attracts water, the glass can attract rain water and use that to clean the dirt off of itself. Another use of nanotechnology in glass is to make it fire-protective. This can be done when a layer of silica nanoparticles is placed between glass panels. This layer turns into a fire-shield when heated.

Pavement is yet one more area that can be improved by nanotechnology. Nanoscale materials can be added to current roads to improve features such as the hardness of the road, the durability, and water and skid resistance [4]. With the application of ZnO_2, it is possible to make hydrophobic roads that cause quicker run-off and help prevent hydroplaning. Nanotechnology can even be used in water treatment. Some of the uses of nanotechnology in water treatment include "...water purification separation and reactive media for water filtration," [4]. Nanotechnology also has the possibility to help improve water quality, availability, and "viability of water resources, such as through the use of advanced filtration materials that enable greater water reuse, recycling, and

desalinization," [4]. Nanoparticles to "clean-up" contaminated areas, They can create new compounds that can have an impact on the environment.

5. Nanotechnology and the Engineers Code of Ethics

An engineer's utmost responsibility is first and foremost to the public and the public's safety. As stated in the American environment…" [6]. This means that if an engineer is aware of a way to improve the lives of people everywhere, and they are capable of doing so, then they are obligated to use that information to help create a better world. Nanotechnology can aid civil engineers in creating a better world. Nanotechnology can lead to a more energy efficient world with the benefits it provides to materials (which have been detailed previously and will not be revisited). In order for a civil engineer to comply with the code of ethics (and essentially do their job), they would have to incorporate nanotechnology into their designs, and the only way for new engineers to be able to do that would be if they are taught about it in school. The ASCE's code of ethics also states that, one of the fundamental canons of engineering is that "Engineers shall continue their professional development throughout their careers, and shall provide opportunities for the professional development of those engineers under their supervision," [6]. This further emphasizes teaching nanotechnology to newer engineers by saying that engineers are obligated to supervise and develop those under them.

Another, very similar code of ethics is the one written by the NSPE. A portion of this code reads that engineers are to "Conduct themselves honorably, responsibly, ethically, and lawfully so as to enhance the honor, reputation, and usefulness of the profession," [7]. For an engineer to do this, that means that they must devote their full efforts into producing the highest quality product that they are capable of creating. For a civil engineer to do this, nanotechnology is important.

6. The Education of Engineering Ethics

Teaching the real ethics of engineering to freshmen students is one of the most vital things for an engineering student. Students need to understand what their futures are truly about and need to understand what they will be doing. Studying the code of ethics will give students this understanding of the jobs as engineers at an early stage, and they will be able to more effectively choose what field is best for them and become a more effective and productive engineer. For civil engineers, looking into the ethics behind educating students about using nanotechnology will give them a large hand up in their education. Not teaching students about nanotechnology is essentially against the code of ethics, as stated above. One of the most widely used forms of teaching engineering ethics is through the case method or real life examples. Having students learn about nanotechnology and how the education of it relates to engineering ethics gives them not only a real-life application of engineering ethics, but a scenario that involves them and could possibly give them a better understanding of an engineer's code of ethics because they are able to relate to the example. It is important to teach an

engineer what is to be expected of him or her and make sure that they are prepared for the future.

Conclusion:

Nanotechnology offers vast amounts of enhancement in the civil engineering field. It has helped to improve the quality of and solved many issues with building materials such as concrete and steel. The employ of nanotechnology has also helped created more efficient and sustainable materials such as self-cleaning and self-repairing concrete and windows. The use of coatings made from nanotechnology helps improve fire-resistance, corrosion protection, insulation, and countless other applications. Nanotechnology can even help to pick up the quality and availability of water. As a possible future civil engineer, this type of technology is of utmost importance to me as we will have to work with nanotechnology in our future. When looking at all of these innovations and improvements upon construction and environmental areas, it can be clearly observed that nanotechnology is of vital importance to the field of civil engineering and needs to be brought into the engineering curriculum at schools. Nanotechnology is essential to the future and advancement of civil engineering; however it cannot contribute to the field if it is not taught on a wider level and to every aspiring civil engineer.

Acknowledgements

We would like to thank our engineering students, as they assisted me throughout the entire writing process. We would also like to thank to the Principal and management of PACE Institute of Technology and Science and Andhra University, Andhra Pradesh for giving us all facilities.

References

Sanchez, Florence, and Konstantin Sobolev. "Nanotechnology in concrete--a review." Construction and Building Materials Nov. 2010.

"List of Nanotechnology Applications." Wikipedia. Wikimedia Foundation, 09 Oct. 2012.

Nanotechnology Doubling the Service Life of Concrete." Nanotechnology Doubling the Service Life of Concrete. N.p., Jan. 2009. Web. 09 Oct. 2012.

Mohan, Prem. "Civil Engineering Seminar Topics: Significance Of Nanotechnology In Construction Engineering.".p., 17 Sept. 2011.

"Code of Ethics." American Society of Civil Engineers. 29 Oct. 2012.

"NSPE Code of Ethics for Engineers." NSPE Code of Ethics for Engineers. National Society of Professional Engineers, 30 Oct. 2012.