

## Chapter 44

# Applications of Nanotechnology in Transportation Engineering

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### ABSTRACT

*Nanotechnology is the latest development in science, where design, construction and applications of various particles involve at least one dimension in nanometers. The nanotechnology has been utilized in many of the scientific and societal disciplines including electronics, medicine, materials science and many more. It has also influenced the broader fields like civil engineering as well as the sub-disciplines including transportation, structural, geotechnical, water resources and environmental engineering. The current focus of the researchers in transportation field is to develop the materials for sustainable transportation facilities, by using the concepts of nanotechnology. The chapter is concerned with the literature review of potential applications of the nanotechnology in transportation engineering including safety, durability, sustainability and economy. The practical applications of the nanotechnology and nanomaterials shall prove to be an asset in transportation engineering.*

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## **HISTORICAL BACKGROUND**

In recent times Nanotechnology had started to attract significant factions of media and investment industry. (Zhu et al, 2004). It is basically concerned with the development of new materials with the help of better understanding of the basic building units of all the materials i.e. atoms and molecules. With the backing of unprecedented funding, nanotechnology is fast emerging as the industrial revolution of the 21<sup>st</sup> century (Siegel et al, 1999). According to Morse, 2004 interpretation of Nano Technology, it can be considered as the future of industries. It would play a vital role in transformation and creation of whole new industries.

Since 1990s, implementation of various areas of nanotechnology has rapidly grown such as science and education, construction and manufacturing, Nano-electronics and information technology, health-care, aeronautics, environment, biotechnology, agriculture, national security and many more.(Sahoo et al. 2007, Tegart 2009, Salerno et al. 2008, Sobolev et al. 2006).

In spite of very huge research and funding in nanotechnology, it is yet much less well-defined and well-structured discipline as compared to some of the other scientific disciplines. A lot of it is still needed to be explored by the researchers in order to better understand and utilize this already very beneficial discipline for the betterment of human beings.

The word “Nano” has a Greek root from the word “Dwarf” representing a billionth (Zhu et al, 2004). Considering this descent, a nanometer is a billionth part of a meter; as small as  $1.25 \times 10^{-6}$  of the diameter of a human hair.

A Japanese engineer, Norio Taniguchi can be regarded as the individual who introduced the term nanotechnology (Taniguchi, 1974). His description encircled precise manufacturing of parts with finishes and tolerances ranging 0.1 to 100nm. It was a major breakthrough as it intended to control materials and engineering measurements beyond the micro scale. Later in 1981, Drexler (Drexler, 1981) pointed out a new approach that involved atom-by-atom manipulative which is more related to the meaning and application today. (Sahoo et al. 2007, Zhu et al. 2004, Salerno et al. 2008, Rodunar 2006, Sanchez et al. 2010, Cao 2006, Islam et al. 2010, Pacheco-Torgal et al. 2011 and Steyn 2008).

Recent interest in nanostructured materials can be attributed to more refined knowledge about creative manipulations of materials on the nanoscale to perform functions, that otherwise would not have been possible. According to Zhu et al. 2004 and Uskokovic 2007 development in this field has allowed more precision enabling a magnified view; hence surfacing various unexpected and unusual features.

## **INTRODUCTION TO NANOTECHNOLOGY**

Many researchers have attempted to define and explain nanotechnology in their own way. Table 1 summarizes some of the attempts to define this emerging scientific discipline.

In a very general prospect, developments in basic physics and chemistry are leading the way for research in the field of nanotechnology. It is because of the fact that these basic branches of science deal with particles on atomic and molecular level and enable materials and structures to perform tasks that are impossible in their original macroscopic form. This drives the fact that evolution in technology and other related scientific areas e.g. physics and chemistry is making a significant contribution in fast and aggressive developments in its research (Chong, 2002).

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