

Chapter 33

Applications of Nanomaterials in Construction Industry

Salim Barbhuiya

Curtin University of Technology, Australia

ABSTRACT

The application of nanomaterials in various applied fields has gained worldwide recognition. Nanomaterials have the ability to manipulate the structure at nano-scale. This leads to the generation of tailored and multifunctional composites with improved mechanical and durability performance. Recognizing this, the construction industry recently has started to use a variety of nanomaterials. The use of these materials is found to improve various fundamental characteristics of construction materials including the strength, durability, and lightness. In this chapter an attempt is made to review the use of various nanomaterials in cementitious system. This is followed by a discussion of the challenges related to their use. Finally, the strategies for using nanomaterials in construction industry for the next ten years are identified.

INTRODUCTION

When the physicist and Nobel laureate Richard Feynman presented, in late 1959 at the California Institute of Technology, USA the lecture *There is plenty of Room at the Bottom* (Feynman, 1960), he outlined what today is known as Nanotechnology. He stated that "...when we have some control of the arrangement of things on a small scale we will get an enormously greater range of possible properties that substances can have, and of different things that we can do.". Years later, the chemist and Nobel laureate Roald Hoffman, at Cornell University, stated that: "Nanotechnology is the way of ingeniously controlling the building of small and large structures, with intricate properties. It is the way of the future, a way of precise, controlled building, with incidentally, environmentally benignness in by design." The physics and chemistry of nanomaterials are fundamentally different from those of their micro-scale counterparts. Dramatic changes and improvements are brought about not only by size reduction, but also by new properties only apparent at the nanoscale. In fact, nanotechnology has changed and will continue to change our vision, expectations and abilities to control the materials world. It is for these reasons, nanotechnology has recently become one of the hottest areas in Research and Development worldwide, and attracted considerable attention in the media and as well as in the investment community.

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The advances in productivity of the construction industry in the 20th century were slow, and development of its technology lagged behind that of other industry sectors. Nanotechnology is a route to achieving real competitive and sustainable growth and innovation within the construction industry. This scientific approach is essential if the potential for a new generation of materials which are of both high performance and more economically viability is to be realised. Nanomaterials are defined as those materials which have at least one dimension (length, width or thickness) below 100 nanometer (1nm), 1nm being a thousandth of a micron, or about 100,000 times smaller than a human hair.

One of the challenges in the field of construction materials has been, and still is, the development of concrete with improved durability. Concrete is a complex multi-phase composite material. The properties, behaviour and performance of concrete are dependent on the nano-structure of the cementitious matrix that glues together and provides integrity. Therefore, the study of the structure of the cement pastes and phenomena in the nanoscale is crucial for the development of new construction materials and applications (Beaudoin, 1999). However, the common approach for the development of durable concrete has mostly consisted of varying the macroscopic parameters which are used to produce concrete. i.e., basically working on the concrete mix design and using different types of SCMs (Mehta, 2000; Mehta & Manmohan, 2006; Concrete Centre, 2007). To a great extent, this approach, motivated mostly by the inertia of the construction industry itself, has slowed down the advance in the deep understanding of construction materials. Within the new paradigm of Nanoscience and Nanotechnology this can no longer continue. Construction materials must be investigated within a scientific approach if a new generation of materials that are both of higher performance and more economically viable is to be created.

NANOMATERIALS IN GENERAL APPLICATIONS

Nano particles are the cornerstones of Nano science and nanotechnology. Nano materials bridge the range of micro and nano scales and their presence enhances the mechanical properties of the material. Over the years nanomaterials have seen widespread acceptance and utilization in various fields of science and technology. Owing to its nano size, this technology has allowed us to fabricate enormous products having advantages over conventional ones; ranging from the materials (nano-fuel cells, catalyst, lubricant, aeronautics, automobiles, telecommunications, energy production, mechanics, biology, medicine etc.

Epoxy resins embedded with nanomaterials are now being developed for better mechanical characteristics. Researchers are also trying to analyze the changes in properties of epoxy-based coatings filled with nanoparticles. Shi et al. (2009) added nanoparticles of Zn, SiO₂, Fe₂O₃ and halloysite clay in a commercial epoxy resin and found enhanced mechanical and chemical properties. In another study Woo et al. (2008) investigated the residual mechanical properties of epoxy organoclay composites after they were exposed to moisture and UV light. Li et al. (2008) analyzed epoxy resin containing various percentages of coiled carbon nanotubes and single-walled carbon nanotubes. The coating formulations were prepared by reacting diglycidyl ether of bisphenol-A (DGEBA) and isophoronediamine. The coating was modified with nanoalumina, silanized nanoalumina and organo-modified montmorillonite nanoclay. It was found that the Young's modulus and hardness increased considerably on addition of nanomaterials. The wear resistance of nanocomposite coating containing nano-TiO₂ and other fillers were studied by Chang et al. (2007). The authors found that the addition of TiO₂ reduces the coefficient of friction but increased the wear resistance and load bearing capacity.

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