Chapter 29
Applications of Nanotechnology in Cement and Concrete Science

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ABSTRACT

The properties of concrete are strongly influenced by the properties of its components and hydrates at the nanoscale. Therefore, application of nanotechnology in cement and concrete science will engender new opportunities for improvement of strength and durability of concrete. The objective of this chapter is to advance the science and engineering of nanotechnology in modifying and monitoring the behaviour and performance of cement and concrete at the nanoscale. The chapter assists in the identification of promising new research and innovations in concrete materials using nanotechnology that can result in improved mechanical properties, volume change properties, durability, and sustainability. The chapter also provides a unique base for scientists, engineers, and practitioners to help set the future direction of the use of nanotechnology in cement and concrete science.

INTRODUCTION

Nanotechnology is an appearing field of research associated to the understanding and command of issue at the nano scale, i.e., at dimensions between approximately 1 and 100 nm. At the nano scale, unique phenomena endow novel submissions. Nanotechnology encompasses nano scale science, technology, and expertise that engage imaging, measuring, modelling, and manipulating issue at this extent scale. Nano scale particles are not new in either environment or research. Latest developments in visualization and estimation systems for characterizing and checking components at the nano scale have led to a blast in nanotechnology-based components in areas such as polymers, plastics, electronics, vehicle constructing and surgery (Duncan, 2011). Issue can display unusual physical, chemical, and biological properties at the nano scale, differing in significant ways from the properties of bulk components and single atoms or substances. Some nanostructured components are more powerful or have distinct magnetic properties contrasted to other forms or sizes of the identical material. Others are better at carrying out heat or electricity (Ma et al., 2008). They may become

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more chemically reactive or contemplate light better or change colour as their dimensions or structure is changed (Baddeley et al., 2007).

Working at the nano scale endows scientists to utilize the unique personal, chemical, mechanical, and optical properties of components that routinely occur at that scale. Specific relevance for solid is the greatly advanced surface locality of particles at the nano scale. As the surface area per mass of a material rises, a greater amount of the material can arrive to communicate with surrounding materials, therefore affecting reactivity. Nanotechnology considers two major advances as shown in Figure 1: the ‘‘top down” approach in which bigger organisations are decreased in dimensions to the nano scale while sustaining their original properties without atomic-level control (e.g., miniaturization in the domain of electronics) or deconstructed from bigger organisations into their lesser composite components and the ‘‘bottom-up” approach, furthermore called ‘‘molecular nanotechnology” or ‘‘molecular constructing” in which components are engineered from atoms or molecular components through a method of assembly or self-assembly.

The mechanical properties of cement and concrete depend to a large extent on structural elements and phenomena, which are effective on a micro- and nanoscale (Shah et al., 2011). Nanotechnology has the potential to engineer concrete with superior properties through the optimization of material behavior and performance needed to significantly improve mechanical performance, durability and sustainability. The use of nanotechnology is likely to make various key breakthroughs in cement and concrete technology. Better understanding and precise engineering of an extremely complex structure of cement-based materials at the nano-level will result in a new generation of concrete, stronger and more durable, with desired stress-strain behavior and possibly possessing the range of newly introduced “smart”

Figure 1. Top down and bottom up approaches in nanotechnology