Development of Concrete Strengths by Nanostructured Materials

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Abstract

In this paper, the effects of several nanostructured materials include SiO_2, TiO_2, Fe_2O_3 and Al_2O_3 on the strengths and other mechanical behaviors of concrete is being reviewed. The SiO_2, TiO_2, Fe_2O_3 and Al_2O_3 nanopartcles can be improved on mechanical behaviors of concrete. The investigation of the concrete mechanical properties is necessary to determine the feasibility of use as well as the impact on durability of structures. The presented results, clearly confirm that by adding nanoparticles to the concrete matrix can significantly increase the overall strength. Mechanical properties were tested in normal and containing nanoparticles concrete. These results were compared together by different factors.

Nano-SiO_2 was found to be more efficient in enhancing strength than silica fume. Addition of 10% nano-SiO_2 with dispersing agents was observed to increase the compressive strength of cement mortars at 28 days by as much as 26%, compared to only a 10% increase with the addition of 15% silica fume. Nano-TiO_2 can accelerate the early-age hydration of Portland cement, improve compressive and flexural. Nano-Fe_2O_3 has been found to provide concrete as well as to improve its compressive and flexural strengths. Also, Nano-Al_2O_3 has been shown to significantly increase the modulus of elasticity (up to 143% at a dosage of 5%) but to have a limited effect on the compressive strength.

Keywords: Concrete Strengths, Nanostructured Materials, Nano-SiO_2, Nano-TiO_2

1. INTRODUCTION

There are many improvements needed in concrete, especially for use in renewal and expansion of the world's infrastructure, e.g. increased durability, decreased brittleness and increased mechanical strength, and routine use of large volumes of nontraditional materials like fly ash. Nanomodification can probably help solve many of these problems. However, concrete has been slow to catch on to the revolution in the nanotechnology that is ongoing in many materials. There are several possible reasons for this lag in the nanoscience and nanotechnology of concrete (NNC). Nano-particles have been gaining increasing attention and been applied in many fields to fabricate new materials with novelty function due to their unique physical and chemical properties.

The first reason is a lack of a basic understanding of chemical and physical mechanisms and structure at the nanometer length scale, without which any attempted modifications at this length scale are only empirically-based and cannot be fully successful. Greater use needs to be made of advances in instrumentation from other fields to help characterize concrete at the nano-scale. In conjunction with this experimental need is the need for improved modeling of concrete at the nanoscale.

Since nanotechnology was introduced by Nobel laureate Richard P. Feynman during his now famous lecture ‘‘There's Plenty of Room at the Bottom,” [1] there have been many revolutionary developments in physics, chemistry, and other sections of science that have demonstrated Feynman's ideas of manipulating matter at an extremely small scale, the level of molecules and atoms, i.e., the nanoscale.

Nanotechnology encompasses two main approaches: (i) the ‘‘topdown” approach, in which larger structures are reduced in size to the nanoscale while maintaining their original properties without atomic-level control (e.g., miniaturization in the domain of electronics) or deconstructed from larger structures into their smaller, composite parts and (ii) the ‘‘bottom-up” approach, also called ‘‘molecular nanotechnology” or ‘‘molecular manufacturing,” introduced by Drexler et al. [2], in which materials are engineered from atoms or molecular components through a process of assembly or self-assembly (Fig. 1). While most contemporary technologies rely on the ‘‘top-down” approach, molecular nanotechnology holds great promise for breakthroughs in materials and manufacturing, electronics, medicine and healthcare, energy, biotechnology, information technology, and national security.

To date, nanotechnology applications and advances in the construction and building materials fields have been uneven [3]. Exploitation of nanotechnology in concrete on a commercial scale remains limited