Chapter 2

Nano-Scale Behavior and Nano-Modification of Cement and Concrete Materials

Liqing Zhang  
Dalian University of Technology, China

Siqi Ding  
Dalian University of Technology, China

Shengwei Sun  
Harbin Institute of Technology, China

Baoguo Han  
Dalian University of Technology, China

Xun Yu  
New York Institute of Technology, USA

Jinping Ou  
Dalian University of Technology, China

ABSTRACT

Cement and concrete materials are widely used, but the development of them comes cross many problems and challenges, such as high energy consumption, high pollution, poor safety and durability, low smart. Nanotechnology is beneficial to understand the behavior of cement and concrete materials at nano-scale. In addition, nanomaterials have remarkable specific properties and functions which can endow cement and concrete materials high mechanical property and durability and multifunctionality. Therefore, applications and advances of nanotechnology and nanomaterials have injected new vitality into cement and concrete materials. This chapter will give a review about nano-scale behavior of cement and concrete materials, the nano modification methods to cement and concrete materials by using

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INTRODUCTION

Cement and concrete are the most widely used construction materials because they are resistant to water, easily formed into various shapes and sizes, the cheapest and readily available everywhere. In the foreseeable future, cement and concrete materials will continue to play an important role in construction materials. However, the development of cement and concrete materials is encountering enormous problems and challenges. Firstly, cement manufacturing consumes high energy and spits out a large amount of carbon dioxide. Additionally, most raw materials of cement are non-renewable. These disadvantages mentioned above are likely to pose great pressure on environment. Secondly, increasing attention has been paid on the security of cement and concrete structures since cement and concrete are brittle materials and usually work with cracks. Thirdly, the durability of cement and concrete structures is a very important issue, in particular during the process of their design and application. Fourthly, cement and concrete materials are complex composites in nature. There are difficulties in how to bring about huge revolution in the cement and concrete material field unless it is available to have a good understanding of cement hydration process, main hydrate phases and so on. Fifthly, the multifunctional and smart cement and concrete materials are required since traditional cement and concrete that just serve as structural materials can not meet the requirement of construction of advanced engineering structures.

Nanotechnology is an emerging field related to the understanding and control of matters at nanoscale. Some remarkably specific properties and functions are exhibited when materials reach nano-size. Recent developments of nanotechnology show significant promise in addressing many of the challenges in various areas. To date, applications and advances of nanotechnology have injected new vitality into cement and concrete materials (Bartos, 2009). The vitality mainly reflects in understanding more about behaviors of cement and concrete materials at nano-scale, fabricating nano-cement and modifying cement and concrete materials by addition of nano-materials. The main advance is that we can learn about basic phenomena in cement at nano-scale (Bartos, 2009; Scrivener & Kirkpatrick, 2008). Jo et al. (2014) used the bead milling to produce ultrafine cement (~220 nm) without
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