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Review

Developments of nano materials and technologies on asphalt materials – A review

Ruoyu Li [a], Feipeng Xiao [a,*], Serji Amirkhanian [a], Zhanping You [b], Jia Huang [c]

[a] Key Laboratory of Road and Traffic Engineering of Ministry of Education, Tongji University, Shanghai 201804, China
[b] Department of Civil and Environmental Engineering, Michigan Technological University, Houghton, MI 49931, United States
[c] School of Materials Science and Engineering, Tongji University, Shanghai 201804, China

HIGHLIGHTS

- Many factors had effects on the properties of nano-modified asphalt binder.
- Nano materials improved low and high temperature performances of asphalt binder.
- Studies on nano modified mixtures were less than those on nano modified binders.
- Economic, ecological and environmental evaluations of need to be considered.

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ABSTRACT

Due to its nature of large surface area and small size, nano-material shows specific characteristics compared to the common material and exhibits some novel properties and incredible features which make it possible to be applied in the field of asphalt pavement as an additive. This review focuses on introducing the main nano materials and related techniques used for nano-modified asphalts and major performance characteristics at various states. Some conventional test results including viscosity, dynamic modulus, stiffness, rut depth, indirect tensile strength and so on were employed to characterize the rheological and engineering performances of nano-modified asphalts and some innovative technologies such as atomic force microscopy, scanning electron microscopy, X-ray diffraction, and Fourier transform infrared spectroscopy were effectively utilized to explore their micro structures and molecular components. It can be found that the addition of nanomaterials could dramatically enhance the properties of an asphalt material such as visco-elasticity, high temperature properties, and the resistances to aging, fatigue and moisture. In addition, nano-particle type, content and production process were mainly studied and other factors such as binder type and particle size also need to be considered to explore the modification mechanism and effect. The properties of both nano-material and original binder played the key roles in determining optimal production process parameters. In addition, the degree of dispersion was governed by some factors such as the mixing temperature, duration and speed.

Contents

* Corresponding author.
E-mail address: fpxiao@tongji.edu.cn (F. Xiao).

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1. Introduction

Recent years, highway pavement construction industry is rapidly progressing all over the world due to a dramatic increase in traffic loads. Traditional pavement materials are hard to meet the practical demands for present and future highway pavement construction. Thus, higher quality, more safety, more reliable and more environment friendly pavement materials are urgently demanded.

As a result, various kinds of modifiers such as crumb rubber, fibers [1–8] are introduced to improve performances of asphalt materials. Styrene-butadiene-rubber (SBR) is also chose to tail the pristine asphalt [9,10]. In addition, Yildirim and his coworkers introduced ethylene glycidyl acrylate (EGA) terpolymer to enhance the performance of original binder [11]. It is true that traditional modifiers can improve performances of the asphalt and mixture. These performances include moisture susceptibility, permanent deformation, fatigue life, anti-aging and so on. However, more and more researchers concentrate on the introduction of nanomaterials to modify the asphalt due to the rapid development of nanotechnology.

Nanomaterial is described as a material with at least one dimension within 1–100 nm. Based on previous research, the properties of nano-composites such as physics, chemistry and biology of were significantly different from their initial ones [12]. Some unique phenomena such as the tunnel effect of macroscopic quantum and surface effect were also been found attributing to the natures of its large surface area and small size. It is noted that

Table 1
Application fields of nanomaterials.

Nanomaterials	Application fields
Carbon nanotubes	1. Adding antibodies to nanotubes to form bacteria sensors to bend the wings of morphing aircraft 2. Adding metal to nanotubes to trap oil spills to increase the capacity of the Li-ion batteries
Nanowires	1. Using zinc oxide nanowires to make the conductive screens of electronic devices 2. Using silver chloride nanowires to decompose organic molecules in polluted water 3. Using iron and nickel nanowires to make dense computer memory
Nanofibers	1. Stimulating the production of cartilage in damaged joints 2. Weaving piezoelectric nanofibers to produce conductive clothing 3. Improving the performance of flame retardant
Nanoceramics	1. Structural composite materials 2. Components anti UV polishing substrates 3. Photocatalytical applications