Editor's Corner

ISSN 1997-1400 Int. J. Pavement Res. Technol. 6(3)

Nanomaterials in Asphalt Pavements

Zhanping You
Department of Civil and Environmental Engineering, Michigan Technological University
Houghton, Michigan, 49931-1295, USA
E-mail: zyou@mtu.edu

DOI:10.6135/ijprt.org.tw/2013.6(3).iv

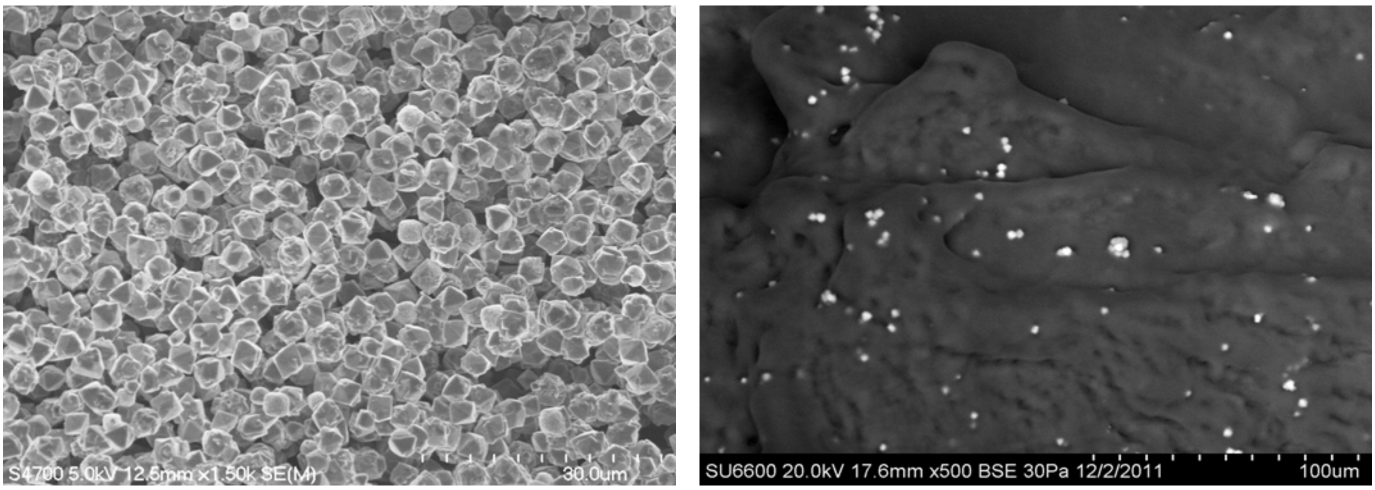
Nanotechnology has been used in various fields. In pavement engineering research, nanotechnology is used as a form of new material, device, and system at the molecular level. A number of researchers have used nanomaterials in Portland cement materials. However, nanomaterial use in asphalt pavement started relatively late. In recent years, some researchers have started to work on the improvement of asphalt materials with nanomaterials in asphalt cement and emulsions. There are various nanomaterials which have been or have potential to be used in asphalt modification; such as nanoclay, nanosilica, nano-hydrated lime, nano-sized plastic powders, or polymerized powders, nano fibers, and nano tubes. A few examples of some related research work are sampled as follows:

Nanoclay, or layered silicates is widely used in the modification of polymer matrices to realize significant improvement in mechanical, thermal and barrier properties per research work conducted in the past decade. One of the most frequently used layered silicates is montmorillonite (MMT), which has a 2:1 layered structure with two silica tetrahedron sandwiching an alumina octahedron[1]. The research on asphalt cement shows that a small percent of nano materials may significantly improve the performance of asphalt materials. For example, in some research work, it was found that 2% of nanoclay in the asphalt binder may increase the shear complex moduli by as much as 184% [1]. This indicates that the rutting resistance of such asphalt is likely improved.

Polymer modified nanoclay (PMN) is also a good candidate for asphalt materials. The nanoclay was first modified with polymer so that the mechanical properties, heat resistance and biodegradability of hybrid materials [1] can be improved. Through this modification process, the permeability of composite material is reduced; while the tear and compression strength is improved [2]. Then, the PMN is introduced into asphalt materials. Observation through Field Emission Scanning Electron Microscopy (FESEM) microstructure images of PMN modified asphalt shows that the agglomeration phenomena occurred [3]. The PMN material had a maximum size of 200-400 nm in terms of aspect ratio. PMN in the asphalt decreases the viscosity of the modified asphalt binders, which may have potential benefit in warm mix asphalt application. The addition of PMN in the control asphalt binder increases the recovery ability of asphalt binder.

Researchers have also used nanotubes, nanosilica and other nanomaterials to modify asphalt materials. Chemical bonds between the asphalt molecules and the nanomaterials shall be fully understood. Figure 1 shows the micro images of nanosilica and its dispersal status in a given asphalt matrix. The nanosilica was well dispersed in asphalt, in general.

Researchers also used such nanomaterials modified asphalt in asphalt mixtures, and characterization tests such as dynamic moduli, creep, fatigue and rutting were performed. In Fig. 2, the rutting depth using asphalt pavement analyzer (APA) illustrated that the addition of 2~4% nanomaterials by weight of asphalt can reduce the rutting depth by almost half. Quite extensive amounts of other nanomaterials confirmed such a trend. Furthermore, it was found that the rut depths of nano- materials modified asphalt mixtures decrease compared to the control mixture, and smaller rutting depth was observed for greater percentage of nanomaterials in mixtures.



(a) FESEM microstructure image of Nanosilica at 1,500x Magnification

(b) FESEM microstructure image of Nanosilica modified asphalt binder

Figure 1: Nanosilica and Nanosilica modified asphalt binder

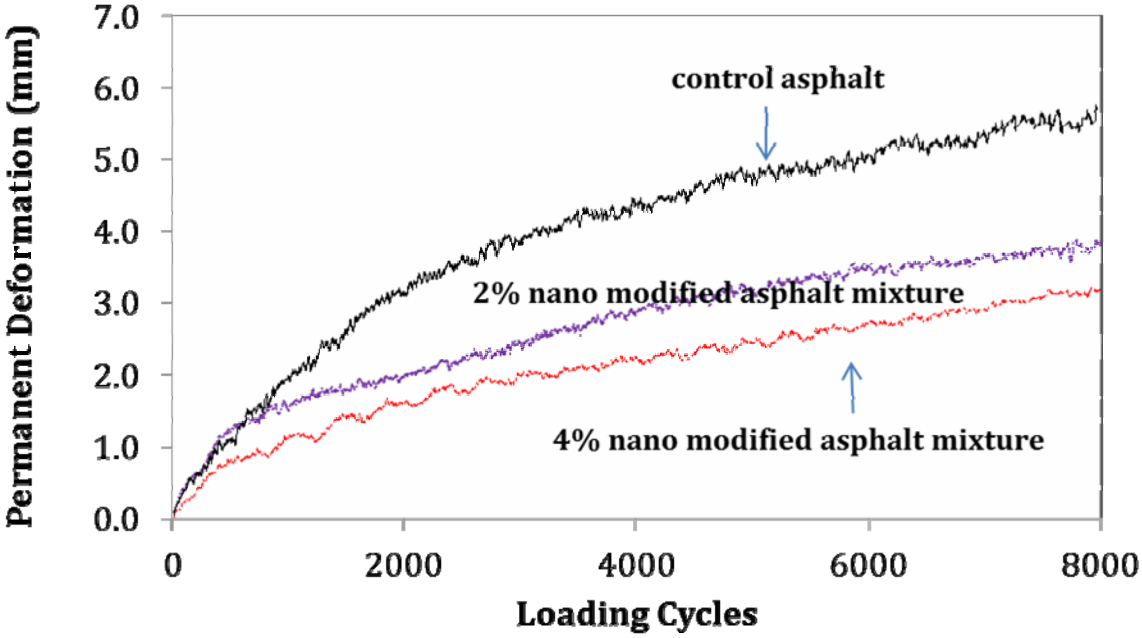


Figure 2 APA rutting test for nano-modified asphalt

It shall be noted that a number of issues on using nanomaterials for asphalt pavements need to be further understood. The study is still in its very early stages with more aspects of mechanical, physio-chemical and morphological characterization of nano-modified asphalt binders and mixtures to be considered in the future. The work described herein cannot be done without the contribution of former students Julian Mills-Beale and Hui Yao of Michigan Technological University, and many collaborators from various institutions.

References

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