Relationship between Rheological Properties of Nano Polymer Modified Asphalt Binder and Permanent Deformation of Asphalt Mixture

E Shaffie[1], J Ahmad[2], A K Arshad[1] , R Putra Jaya[3], N Mohamad Rais[4] and M A Shafii[5]

[1] Institute for Infrastructure Engineering and Sustainability Management (IIESM), Universiti Teknologi MARA, Shah Alam, Selangor, Malaysia
[2] Faculty of Civil Engineering, Universiti Teknologi MARA, Uitm Shah Alam, Selangor, Malaysia.
[3] Faculty of Civil Engineering and Earth Resources, Universiti Malaysia Pahang, 26300 Gambang, Pahang, Malaysia.
[4] Malaysia Institute of Transport (MITRANS), Universiti Teknologi MARA, Shah Alam, Selangor, Malaysia
[5] Faculty of Engineering and Built Environment, SEGi University, Petaling Jaya, Selangor, Malaysia.

Received 28 June 2011; accepted 5 August 2011, available online 24 August 2011

Abstract: Asphalt binder plays an important part in determining many aspects of road performance. However, the rheological properties of asphalt binder are very complex and the parameters depend purely on the viscosity, various loading time and temperature. Therefore, relationship study on asphalt binder rheological properties and asphalt mixture is vital to predict the performance of the mixture. This paper evaluates the relationship between rheological asphalt binder and asphalt mixture performance containing nanopolymer modified binder. Five sets of asphalt binder rheology were tested to determine their viscosity, effect of short term and long term aging using the dynamic shear rheometer (DSR). The asphalt mixtures performance test was then conducted to evaluate the permanent deformation of the mix. Findings from this study indicate that the rheological properties of asphalt binder acts as indicator for the asphalt mixture performance. The G*/sin δ and viscosity of the asphalt binder significantly agree with the resilient modulus and rut depth results obtained. The dependent (resilient modulus at 40^{o}C and rut depth) and dependent (G*/sin δ and viscosity) variables show that these variables significantly affects each other. An effective prediction models can also be developed according to predicted and measured permanent deformation values

Keywords: Rheological Properties, Viscosity, Permanent Deformation, Resilient Modulus and Nanopolymer

1. Introduction

Over the years, pavement failures due to permanent deformation or rutting has been a big challenge to the authority to maintain existing road networks. Increase in traffic volume especially heavy vehicles and environmental condition contributes to the deterioration of the pavement. Recently, many studies have been conducted on modification of asphalt binder using different types of polymer modifier. The addition of polymers typically increases the rigidity of the asphalt binder and improves on the temperature susceptibility. Polymer modified asphalt binders also showed improvement to the mechanical properties of hot mix asphalt (HMA) [1]. Several properties of asphalt mix are improved which include fatigue life, temperature susceptibility and resistance to permanent deformation [2-4]. All of these attributes improve the overall pavement performance.

Modification of the asphalt binder can increase temperature stiffness, which boosts resistance to rutting, bleeding, and flushing. It can also reduce low temperature stiffness, improve fatigue resistance, improve asphalt age hardening resistance and provide stiffer hot mix layers [5-7]. From literature review, few studies were conducted using nano polymer such as nanoclays, carbon nanotubes, nanopolyacrylate, etc. The effectiveness of nanopolymer in altering hierarchical structure of composite materials due to their surface properties has seen a tremendous development in recent years [6-9]. Zafari also conducted a study on the potential benefits of nanosilica particles in asphalt mixtures and concluded that introduction of nanosilica to asphalt binder can improve the anti‐aging property, rutting performance and rheological properties of asphalt binder [10]. Study by Yao reported that addition of nanoclay and carbon microfiber improves the permanent deformation mixtures performance. In addition, nanosilica modified asphalt binder performed better for rutting and fatigue cracking resistance compared to conventional asphalt binder and carbon microfiber modified asphalt [11].

The study on rheological properties of asphalt binder is an important phenomenon to determine the overall performance of modified asphalt binder. The

*Corresponding author: