UNIVERSITI TEKNOLOGI MARA

PERFORMANCE OF POROUS ASPHALT WITH NANOSILICA MODIFIED ASPHALT BINDER

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ABSTRACT

Porous asphalt (PA) is a flexible pavement layer with high interconnected air voids and constructed using open-graded aggregates. Due to high temperature environment and increased traffic volume in Malaysia, PA may have deficiencies particularly in rutting and stiffness of the mix. A possible way to improve these deficiencies is to improve the asphalt binder used. Binder is normally modified using polymer materials to improve its properties. However, nanotechnology presently is being gradually used for asphalt modification. Nanosilica (NS), a by product of rice husk and palm oil fuel ash was used as additive in this study. The aim of this study was to enhance the rutting resistance and stiffness performance of PA using NS. This study focused on the performance of PA with NS-modified binder (NS-MB) to produce better and more durable PA. The involved experimental work which was divided into three phases. Asphalt binder evaluation and performance of the NS-PA mixture was carried out in the first and second phase. Physical tests using Penetration, Softening Point, Ductility, Storage Stability and Rotational Viscosity showed that NS modified binder (NS-MB) can resist high temperature susceptibility. Rheological test using Dynamic Shear Rheometer also showed that NS-MB was capable in enhancing its performance under various temperatures and stresses. Morphological test using Atomic Force Microscopy, Scanning Electron Microscopy and X-ray Diffraction showed that NS was dispersed well in the asphalt binder. Chemical properties using Fourier Transform Infrared analysis showed that NS-MB was capable in reducing the oxidation process (ageing) of asphalt binder. Mechanical properties tests such as Permeameter, Cantabro Loss, Binder Draindown, Resilient Modulus, Indirect Tensile Strength, Dynamic Creep, Dynamic Modulus and Wheel Tracking showed that NS was capable in enhancing the abrasion resistance, binder draindown resistance, stripping resistance, stiffness and rutting resistance of PA. Based on these results of these phases, the addition of NS is capable in enhancing the overall performance of PA. Then, three statistical models were developed in phase three of this study to evaluate the performance of PA in terms of rutting and dynamic modulus. The first model relates the rut depth of PA with rutting parameters of asphalt binder. Then, the second model relates dynamic modulus of PA with temperature, frequency, amount of NS and nominal maximum aggregate size. The last model relates dynamic modulus of PA with rutting parameters of asphalt binder. It is recommended that a study is carried out in the future to evaluate and verify the field performance of NS-PA mix in flexible pavement.

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CHAPTER ONE
INTRODUCTION

1.1 Background of Study

Porous asphalt (PA) has been well-known for its advantages in improving skid resistance of pavement during rain, reducing splashing effects, and producing lower riding noise (Liu & Cao, 2009). These criteria exist due to the high porosity possessed by porous asphalt layer which allows for high drainage capability of surface run-off. According to the Public Works Department of Malaysia (*JKR/SPJ/2008*, 2008), PA should have a total percentage of voids between 20 % to 25 % which is relatively high compared to conventional hot mixed asphalt. The high voids content in PA have been enabled through the use open-graded type of aggregates. The gradation of PA consists mainly of coarse aggregates with dimension size larger than 2.36 mm (No. 10 sieve) together with small amount of fine aggregates (not more than 15 %) and also mineral filler not exceeding 5 % of the total aggregate weight (*JKR/SPJ/2008*, 2008). Hence, this type of gradation produces a relatively high interconnected air voids after compaction.

PA is generally considered as a non-structural layer of flexible pavement. However, it should possess sufficient strength in bearing the external loads imposed by vehicular traffic. Some mechanical properties owned by conventional asphalt layer such as dynamic modulus, rutting resistance, stripping potential, resilient modulus, indirect tensile strength, and stability should also be evaluated for PA. This is important since PA forms the uppermost layer of flexible pavement, thus receiving the loads from moving traffic directly. The mechanical properties of PA greatly depends on several factors and one of them is related to the binder used. Figure 1.1 and Figure 1.2 illustrate PA and its application at a parking lot.