



UNIVERSITI PUTRA MALAYSIA

**EFFECT OF PARTICLE SIZE AND TYPE ON ASPHALT-FILLER MASTIC
PROPERTIES AND STONE MASTIC ASPHALT (SMA) PERFORMANCE**

ELTAHER ELZARROUG ABURKABA

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**BY
ELTAHER ELZARROUG ABURKABA**

**This Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia,
in Fulfillment of the Requirement for the Degree of Doctor of Philosophy**

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DEDICATION

This work is passionately dedicated to my wife Annette and daughter Karima and sons Khalid, Omar, and Jamal who have undergone much endurance and patience throughout the course of my study.



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Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfillment of the requirement for the degree of Doctor of Philosophy

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May 2012

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Stone Matrix Asphalt (SMA) is a gap-graded hot mixture that has higher proportion of coarse aggregate, lower proportion of middle-size aggregates, and higher proportion of mineral filler than conventional mixture. Because of the high quantity of mineral filler (8-12%), the type and size of this fraction should play a major role in the properties of these mixtures and their mastics. A great deal of research has been reported on mineral fillers in the past, however, very little information is available regarding the effect of filler particle size (gradation) and type on the characteristics, viscoelastic properties of asphalt-filler mastics, and mixture properties.

This study presents a laboratory investigation into the effects of different fillers on properties of asphalt-filler mastics and SMA mixtures. The fillers physical and chemical properties were characterized using imaging techniques and traditional mechanical testing. Four filler types and three filler particle size (passing the 75, 75/20, and 20 micron sieve) were used to obtain the master curves of mastics and to characterize the stiffening effect of filler particle size and type in mastics using new testing techniques being developed within the SHRP program for testing asphalt binders using the Dynamic Shear Rheometer (DSR) in accordance with AASHTO T315 at different temperatures. The effects of filler on the characteristics of SMA

mixtures were also investigated in accordance with AASHTO and ASTM standards. The properties of SMA mixtures evaluated include optimum asphalt cement (AC) content, indirect tensile strength (IDT), Permanent deformation (Rutting), and tensile strength ratio (TSR).

The filler particle size distribution and filler type have been found to have a significant influence on asphalt-filler mastics, and the mechanical properties of SMA mixtures. Fillers with medium size particles (50/50 proportion passing 75/20 micron) tend to behave in the most predictable manner. However, the inconsistent trends were observed when the fillers are finer than 20 micron, or when the fillers are coarser (75 micron) and lacking material finer than 20 micron. The filler type has a definite effect on asphalt binder, mastic, and mixture properties; each filler type differs in the amount of property enhancement and performance characteristic.

The test data and observations revealed that the combination of coarse to medium size particles had the highest impact on asphalt-filler mastics and SMA mixture properties. They generally performed better than the fine particle size alone (passing the 20 micron sieve) in improving the engineering properties of SMA mixtures and providing resistance against permanent deformation and fatigue cracking while the fine particle size showed better resistance to moisture induced damage than the other two fractions.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia
Sebagai memenuhi keperluan untuk Ijazah Doktor Falsafah

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Batuan Asfalt Mastik (SMA) adalah campuran panas bahan turapan yang mempunyai jurang jujuk gradasi terdiri daripada campuran agregat kasar yang tinggi, agregat bersaiz sederhana yang rendah dan berkandungan tinggi bagi campuran halus mineral berbanding dengan campuran turapan konvensional. Oleh kerana kandungan campuran halus mineral yang agak tinggi tersebut (8-12%), jenis dan pecahan saiz partikel bagi campuran halus ini memainkan peranan penting dalam menentukan ciri-ciri dan sifat mastik bahan turapan SMA. Terdapat pelbagai penyelidikan dan kajian telah dilaporkan berhubung dengan campuran halus mineral ini pada masa lalu. Walau bagaimanapun hanya sedikit informasi yang boleh didapati berhubung dengan kesan daripada pengaruh gradasi saiz partikel, ciri-ciri mengikut jenis, sifat keanjalan asfalt – mastik dan juga sifat-sifat campuran SMA pada keseluruhannya.

Kajian ini menunjukkan penyiasatan makmal terhadap kesan campuran halus mineral yang berlainan sifat dan ciri kepada campuran mastik SMA. Ciri-ciri kimia dan fizikal bahan campuran mineral halus ini telah diklasifikasikan menggunakan teknik pengimbasan dan teknik tradisi ujian mekanikal. Campuran halus mineral ini terdiri

daripada empat jenis dengan tiga julat taburan partikel (melempi ayakan 75, 75/20, dan 20 mikron) digunakan untuk memperolehi lengkungan mastik utama dan mengenalpasti kesan pengukuhan oleh pelbagai jenis dan taburan partikel tersebut. Kaedah dan teknik baru yang dibangunkan dibawah program SHRP untuk ujian asphalt iaitu ujian Reometer Ricih Dinamik (DSR) selaras dengan spesifikasi AASHTO T315 pada suhu yang berbeza telah digunakan bagi tujuan penyiasatan prestasi mastik ini disamping juga kaedah – kaedah lain selaras dengan standard AASHTO dan ASTM. Penilaian ciri-ciri dan sifat SMA ini juga telah dilaksanakan dari segi kandungan optimum asphalt, Ujian Kekuatan Tegangan Tidak Langsung (IDT), Ujian Deformasi Kekal (Mendapan) dan Ujian Kekuatan Perkadaran Tegangan (TSR).

Jenis dan taburan saiz partikel campuran halus mineral didapati mempunyai pengaruh yang signifikan ke atas mastik campuran halus mineral-asfalt dan sifat-sifat mekanikal campuran SMA. Campuran halus mineral bersaiz sederhana (50/50 pecahan kandungan melebihi ayakan 75/20 mikron) cenderung untuk mempunyai sifat dalam corak seperti yang diramalkan. Walau bagaimanapun, apabila campuran halus mineral adalah lebih halus daripada 20 mikron, atau apabila campuran halus mineral adalah lebih kasar (75 mikron) yang berkekurangan bagi bahan yang lebih halus daripada 20 mikron digunakan, corak sifat dan ciri-ciri yang tidak konsisten telah diperhatikan dalam penyiasatan kajian ini. Jenis campuran halus mineral didapati mempunyai kesan yang jitu pada setiap jenis asphalt, mastik campuran SMA. Setiap jenis campuran halus mineral berbeza dalam jumlah peningkatan sifat fizikal dan ciri prestasi.

Hasil daripada data ujian yang diperolehi, pemerhatian menunjukkan bahawa kombinasi partikel kasar dan halus mempunyai impak yang sangat tinggi terhadap mastik campuran halus mineral – asphalt dan ciri-ciri campuran SMA keseluruhannya.

Pada dasarnya, kombinasi partikel kasar dan halus campuran mineral ini menunjukkan prestasi yang lebih baik daripada campuran mineral yang mempunyai saiz partikel halus sahaja (melempi ayak 20 mikron) dalam memperbaiki sifat kejuruteraan campuran SMA dari segi rintangan terhadap deformasi kekal dan retak kelesuan. Walaubagaimanapun saiz partikel halus menunjukkan rintangan yang lebih baik kepada kerosakan lembapan berbanding dengan dua pecahan campuran halus mineral yang lain.



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I certify that a Thesis Examination Committee has met on 7 September 2012 to conduct the final examination of El Taher El Zarroug Aburkaba on his thesis entitled “Effects of Particle Size and Type on Asphalt-filler Mastic Properties and Stone Mastic Asphalt performance” in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U. (A) 106] 15 March 1998. The committee recommends that the student be awarded the Doctor of Philosophy.

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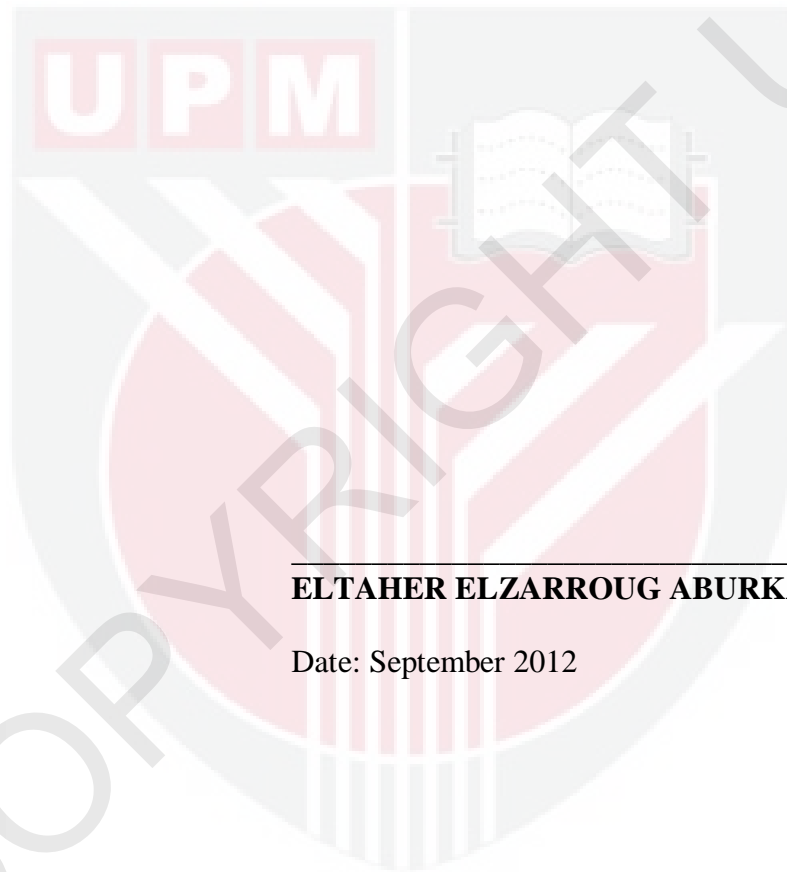
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DECLARATION

I declare that the thesis is my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously and is not concurrently, submitted for any other degree at Universiti Putra Malaysia or other institutions.



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Date: September 2012

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