UNIVERSITI PUTRA MALAYSIA

EVALUATION OF PROPERTIES OF STONE MASTIC ASPHALT SLAB PRODUCED USING A NEW ROTARY COMPACTOR

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BY

MOHAMMAD SAEED POURTAHMASB

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfillment of the Requirements for the Degree of Master of Science

March 2009

Dedicated to my beloved family:

Dad, Mom

&

My Sister

Abstract of thesis presented to the Senate of University Putra Malaysia in fulfillment of the requirement for the degree of Master of Science

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March 2009

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Recent laboratory studies have shown that the compaction can highly affect the performance of Stone Mastic Asphalt (SMA) mixtures. California kneading compactors, Gyratory compactors and Marshall impact compactors are being used as SMA compactors in the mix design methods. But according to the performance of the SMA compacted specimens, none of them could simulate the field compaction one hundred percent. Breaking down of the aggregates during compaction is one of the most extensive problems in road mixtures and if that becomes prevalent, the mixture may not meet the minimum VMA (void in mineral aggregate) and VCA (void in coarse aggregate) requirements.

In this study, the newly developed Rotary compactor was introduced as a new equipment for laboratory compaction to reduce the previous laboratory compactor problems and to have better field simulation. Physical properties of materials such as aggregates, bitumen and fiber have been considered as one of the objectives in this research. So the physical properties of the asphalt mixture materials were determined in accordance with relevant international standards such as ASTM, AASHTO and BS. The weight of required materials per each Rotary slab was approximately130kg and Marshall mix design was selected as a mix design method to measure the Optimum Asphalt Content (OAC) and based on the Asphalt Institute method the OAC was obtained 6%. A total of three SMA slabs were prepared in accordance with UPM in-house protocol for Rotary compactor and 88 core specimens with 100mm diameters and 8 core specimens with 200mm diameter were cored out and subjected to performance tests.

SMA core specimens with 100mm diameters were tested for density, air void, stability, flow, resilient modulus, indirect tensile strength (IDT), moisture induced damage and fatigue. Also, 8 core specimens with 200mm diameters were subjected to Loaded Wheel Tracking (LWT) test to measure the rut resistance level of the Rotary SMA specimens. Finally, the performance test results were tabulated and analyzed. The entire analysis indicated that the results can be accepted in terms of performance of the SMA core specimens compacted using the newly developed Rotary compactor. It can be concluded that Rotary compactor can be used as a new heavy duty laboratory compactor.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains.

PENILAIAN CIRI-CIRI KEPINGAN STONE MASTIC ASPHALT YANG DIHASILKAN MELALUI CIPTAAN TERBARU MESIN PEMADAT BERPUTAR

Oleh

Mohammad Saeed Pourtahmasb

Marc 2009

Penyelia: Prof. Madya Ratnasamy Muniandy, PhD

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Kajian di makmal kebelakangan ini menunjukkan bahawa pemadatan adalah sangat mempengaruhi prestasi campuran Stone Mastic Asphalt (SMA). Pemadat menguli California, pemadat Gyratory dan pemadat hentaman Marshalladalah antara yang biasa digunakan sebagai pemadat untuk campuran SMA. Akan tetapi berdasarkan prestasi spesimen SMA yang telah dipadatkan, hasilnya tiada pun spesimen yang menyerupai seratus peratus seperti pemadatan di tapak.

Pemecahan agregat sewaktu pemadatan adalah salah satu masalah yang rumit untutk adunan SMA dan jika masalah ini berterusan, campuran tidak akan dapat mencapai

tahap minima untuk kandungan rongga di dalam agregat mineral (VMA) dan kandungan rongga di dalam agregat kasar.

Dalam kajian ini, sejenis mesin pemadat Rotary yang baru direka telah diperkenalkan sebagai alat pemadatan di makmal untuk mengurangkan masalah-masalah yang dialami jika menggunakan mesin-mesin pemadat yang biasa digunakan sebelum ini. Pemadat Rotary ini juga bertujuan untuk meningkatkan kesamaan spesimen di makmal seperti pemadatan di tapak. Sifat-sifat fizikal bahan-bahan campuran seperti agregat, bitumen dan fiber telah diambil kira sebagai salah satu subjek dalam kajian ini.

Sifat-sifat tersebut ditentukan berdasarkan standard antarabangsa seperti ASTM, AASHTO dan BS. Berat bahan-bahan yang diperlukan untuk setiap slab Rotary adalah dianggarkan 130kg dan campuran Marshall telah dipilih untuk menetukan kandungan asfalt yang optimum (OAC) dan berdasarkan kaedah dari Asphalt Institute, kandungan OAC yang diperoleh adalah enam peratus.Sejumlah tiga slab SMA disediakan menurut protokol UPM untuk mesin pemadat Rotary, 88 spesimen berdiameter 100mm dan 8 spesimen berdiameter 200mm akan dijadikan subjek untuk ujian prestasi.

Spesimen SMA berdiameter 100mm telah diuji dengan ujian ketumpatan, ujian rongga udara, ujian kestabilan, ujian ketahanan modulus, ujian kekuatan tegangan tidak langsung (IDT), ujian kelembapan penyebab kerosakan dan ujian retakan kelemahan teraruh (*fatigue test*). Manakala lapan spesimen berdiameter 200mm akan diuji untuk ujian Loaded Wheel Tracking (LWT) untuk menguji paras *rut resistance.* Akhir sekali,

keputusan ujian prestasi dimasukkan kedalam jadual dan dianalisis. Analisis menunjukkan ujian-ujian prestasi spesimen SMA menggunakan mesin pemadat Rotary yang baru ini boleh diterima pakai. Dapat disimpulkan bahawa mesin pemadat Rotary boleh digunakan sebagai mesin pemadat yang baru untuk kegunaan di makmal supaya dapat menghasilkan simulasi spesimen seperti pemadatan di tapak.

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Last but not least, I appreciate my family, which I owe a big debt of gratitude to them for their full support during my entire life.

APPROVAL SHEETS

I certify that an Examination Committee has met on **31.03.2009** to conduct the final examination of **Mohammad Saeed Pourtahmasb** on his Master of Science thesis entitled **" EVALUATION OF THE PROPERTIES OF STONE MASTIC ASPHALT SLABS PRODUCED USING A NEWLY DEVELOPED ROTARY COMPACTOR (ROTOCOM)"** in accordance with Unversiti Pertanian Malaysia (HIGHER Degree) Act 1980 and Universiti Pertanian Malaysia (High Degree) Regulation 1981. The committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

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This thesis submitted to the senate of Universiti Putra Malaysia and has been accepted as fulfillment of the requirement for the degree of Master of Science. The members of the Supervisory Committee are as follows:

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DECLARATION

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

MOHAMMAD SAEED POURTAHMASB

Date: 14 May 2009

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LIST OF ABBREVIATIONS / NOTATIONS / GLOSSARY OF TERMS

AASTO	American Association of State Highway and Transportation Officials
ACV	Aggregate Crushing Value
AIV	Aggregate Impact Value
ASTM	American Society for Testing and Materials
BS	British Standard
DGA	Dense Graded Asphalt
HMA	Hot Mix Asphalt
IDT	Indirect Tensile Strength
LVDT	Linear Variable Differential Transducer
LWT	Loaded Wheel Tracking
MATTA	Material Testing Apparatus
NAPA	National Asphalt Pavement Association
OAC	Optimum Asphalt Content
OGA	Open Graded Asphalt
PG	Performance Grade
PSV	Polished Stine Value
SGC	Superpave Gyratory Compactor
SHRP	Strategic Highway Research Program
SMA	Stone Mastic Asphalt

SSD	Saturated Surface Dry
TMD	Theoretical Maximum Density
TSR	Tensile Strength Ratio
UPM	University Putra Malaysia
VFA	Voids Field with Asphalt
VMA	Voids in Mineral Aggregates
VPM	Vibrations Per Minute
VTM	Voids in Total Mix

CHAPTER 1

INTRODUCTION

1.1 General Background

Stone mastic asphalt was developed in Germany in the 1960’s and widely used throughout the world as a preferred asphalt surfacing. Stone Mastic Asphalt (SMA) provides a deformation resistant, durable surfacing material, suitable for heavily trafficked roads.

In recent years, the need for providing a safe and efficient road system has been a cause of concern to the Malaysian government. Road accident statistics indicate a marked increase in fatalities on Malaysian roads. The major reasons for building new expressways in Malaysia are the increasing number of vehicles along federal routes, the opening of major ports and airports in Malaysia, and the increasing population in major cities and towns of Malaysia.

The Civil Engineering Department of University Putra Malaysia (UPM) is one of the pioneer organizations in highway and transportation research and many studies have been carried out on flexible pavement. Stone Mastic Asphalt research work in UPM started in late 1994 with the Ministry of Science and Technology grant to develop SMA for Malaysian roads.

SMA has a high coarse aggregate content that interlocks to form a stone skeleton that resists permanent deformation. The stone skeleton is filled with mastic of bitumen and filler to which fibers are added to provide adequate stability of bitumen and to prevent drainage of binder during transport and placement. Typical SMA composition consists of 70−80% coarse aggregate, 8−12% filler, 6−7% binder, and 0.3% fiber (Brown & Mallick., 1994).

Recent laboratory studies have shown that compaction can highly affect the performance of Stone Mastic Asphalt (SMA) mixtures. The goal of compaction is to achieve the optimum air void content and compressing the coated stones together by increasing the density of the mix to the considered level of compaction with a minimum change in the gradation and structure. Inappropriate compaction may draw the binder to the surface of SMA causing flushing of the surface and loss of texture or aggregate segregation.

California kneading compactor, Gyratory compactor and Marshall Hammer are being used as SMA compactors due to mix design method. But according to the performance of the SMA compacted specimens, none of them could simulate the field compaction one hundred percent. Achieving consistency in compaction, both in the laboratory and on site is necessary if accurate correlation is to occur between laboratory performance and observed site behaviour. It has been demonstrated that differing laboratory compaction methods can produce volumetrically identical specimens but with widely varying mechanical performance (Alistair et al., 1999).