PROPERTIES OF STONE MASTIC ASPHALT SLABS COMPACTED USING A NEWLY DEVELOPED ROLLER COMPACTOR

By

FAUZAN MOHD. JAKARNI

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

November 2006

DEDICATION

This thesis is dedicated specially to:

My lovely wife:

Nur Hanani Mansor

My parents:

Mohd. Jakarni Mohd. Said

&

Bedah Ishak

My parents-in-law:

Mansor Mohd. Lazim

&

Zaniah Hashim

To my brothers and sisters

&

All family members and friends

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Master of Science

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Chairman : Associate Professor Ratnasamy Muniandy, PhD

Faculty : Engineering

Pavement mix design procedures and specifications are usually derived from laboratory experiments conducted on materials that are to be used in the field. Therefore, laboratory experiments should be able to simulate to a high degree the conditions in the field, especially in term of compaction procedures. Stone Mastic Asphalt (SMA) is one type of asphalt mixtures that is highly dependent on the method of compaction as compared to conventional Hot Mix Asphalt (HMA) mixtures. As the future trends in asphalt pavement industry all over the world is gradually changing over to SMA due to its excellent performance characteristics, a suitable laboratory compaction method that can closely simulate field compaction is evidently needed. Therefore, this study is conducted in order to evaluate the Stone Mastic Asphalt (SMA) properties compacted using the newly developed Turamesin and thus to determine the ability and performance of Turamesin as an improved laboratory compaction method. This study comprises of three stages. In Study 1, a literature review was conducted in order to establish suitable methods for slab

compaction procedures. Preliminary compactions were then performed and data were analyzed to develop correlation between different compactive efforts and properties of the compacted slabs. From the analysis, 8 kgf/cm^2 of applied pressure and 75 numbers of passes of the roller compactor were required to achieve the ideal void content of 4%. Also, Turamesin was found to be capable of compacting slab within duration of 15 minutes, enabling 16 cylindrical core specimens of 100 mm to be cored out. In Study 2, a total of 15 slabs from three different types of asphalt binders, namely Grade 60/70, Grade PG76 and Grade 80/100 were prepared, measured and analyzed for consistency in terms of length, width and thickness. The results have indicated that the variability of the measured parameters of length, width and thickness were generally low as indicated by 0.26%, 0.18% and 1.44% of coefficient of variation respectively. Thus, it can be concluded that the slabs were uniformly compacted in terms of physical dimensions, resulted in average area of 590 mm by 500 mm and thickness ranging from 60 mm to 68 mm. Prior to Study 3, 100 mm and 200 mm diameter cylindrical core specimens were cored out from previously prepared SMA slabs, before being subjected to bulk density, air voids and other performance tests. Based on the analysis, it was found that the SMA slabs have uniformly distributed properties throughout the slabs with low percentage of coefficient of variation. The measured properties tend to agree with the expected performance and comparable to the common SMA mixtures performance. Therefore, it can be concluded that Turamesin was capable in compacting SMA slabs with uniformly distributed properties throughout the slab which indicate the efficiency and outstanding performance of Turamesin.

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

SIFAT PAPAK ASFALT MASTIK BATUAN YANG DIPADATKAN DENGAN MENGGUNAKAN PEMADAT GOLEK YANG BARU DIBINA

Oleh

FAUZAN MOHD. JAKARNI

November 2006

Pengerusi : Profesor Madya Ratnasamy Muniandy, PhD

Fakulti : Kejuruteraan

Prosedur dan spesifikasi bagi rekabentuk campuran turapan biasanya diperolehi daripada eksperimen di makmal yang dijalankan ke atas bahan-bahan yang akan digunakan di lapangan. Maka, eksperimen di makmal haruslah mampu untuk mensimulasikan keadaan di lapangan dengan sebaik mungkin, terutamanya dari segi kaedah pemadatan. Asfalt Mastik Batuan (SMA) merupakan sejenis campuran asfalt yang amat bergantung kepada kaedah pemadatan, jika dibandingkan dengan Asfalt Campuran Panas (HMA). Disebabkan oleh arah tuju industri turapan di seluruh dunia mula beralih kepada campuran SMA, maka satu kaedah simulasi pemadatan lapangan di makmal adalah amat diperlukan. Kajian ini dijalankan untuk menentukan sifat-sifat Asfalt Mastik Batuan (SMA) yang dipadatkan dengan menggunakan Turamesin yang baru dibina dan seterusnya untuk menentukan keupayaan dan pencapaian Turamesin sebagai satu kaedah pemadatan di makmal yang lebih baik. Kajian ini terdiri daripada tiga peringkat. Di dalam Kajian 1, rujukan ilmiah telah dibuat bertujuan untuk menerbitkan satu kaedah pemadatan papak yang sesuai. Pemadatan awalan

kemudiannya dijalankan, dan data yang diperolehi dianalisa untuk mengkorelasikan pelbagai input pemadatan dengan sifat-sifat papak. Daripada analisa tersebut, tekanan gunaan sebanyak 8 kgf/cm^2 dan 75 laluan bagi pemadat golek diperlukan untuk mencapai nilai kandungan lompang optimum sebanyak 4%. Turamesin didapati mampu untuk memadatkan papak dalam tempoh 15 minit dan sebanyak 16 sampel teras silinder berdiameter 100 mm dapat diperolehi. Di dalam Kajian 2, sebanyak 15 papak daripada tiga jenis asfalt iaitu Gred 60/70, Gred PG76 dan Gred 80/100 telah disediakan, diukur dan dianalisa bagi menentukan nilai kekonsistenan. Keputusan yang diperolehi menunjukkan bahawa keberubahan parameter yang diukur dari segi panjang, lebar dan tebal papak secara umumnya adalah rendah, iaitu sebanyak 0.26%, 0.18% and 1.44% bagi nilai pekali variasi. Maka, dapatlah disimpulkan bahawa papak-papak tersebut telah dipadatkan untuk membentuk dimensi fizikal yang seragam dengan nilai keluasan purata sebanyak 590 mm kali 500 mm dan julat bagi ketebalan di antara 60 mm dan 68 mm. Bagi Kajian 3, papak-papak tersebut dikorek untuk mendapatkan sampel teras silinder berdiameter 100 mm dan 200 mm, sebelum analisa ketumpatan pukal, lompang udara serta pelbagai ujian pencapaian dijalankan. Berdasarkan kepada analisa tersebut, kesemua sampel papak didapati mempunyai keseragaman dari segi penyebaran sifat-sifat terukur, berdasarkan kepada nilai pekali variasi yang rendah. Sifat-sifat terukur didapati cenderung untuk menepati ciri-ciri jangkaan dan setanding dengan ciri-ciri campuran SMA secara umumnya. Kesimpulannya, Turamesin didapati mampu untuk menghasilkan papak yang mempunyai keseragaman dari corak penyebaran pelbagai sifat dan seterusnya membuktikan kecekapan dan sifat menonjol bagi Turamesin.

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I certify that an Examination Committee met on 9th November 2006 to conduct the final examination of Fauzan Mohd. Jakarni on his Master of Science thesis entitled "Evaluation of Stone Mastic Asphalt Properties Using the Newly Developed Roller Compactor" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 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 fulfilment of the requirement for the degree of Master of Science. The members of the Supervisory Committee are as follows:

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Date: 16 JANUARY 2007

DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declared that it has not been previously or concurrently submitted for any other degree at UPM or other institutions.

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FAUZAN MOHD. JAKARNI

Date: 18 DECEMBER 2006

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LIST OF ABBREVIATIONS/NOTATIONS/GLOSSARY OF TERMS

AASHTO	American Association of State Highway and Transportation Officials
ACC	Asphalt Concrete Course
AMIR	Asphalt Multi-Integrated Roller
APA	Asphalt Pavement Analyzer
ASTM	American Society for Testing and Materials
BS	British Standard
COV	Coefficient of Variation
DNRL	Danish National Roads Laboratory
ESALs	Equivalent Single Axle Load
HIPAC	Hot Iron Process Asphalt Compaction
HMA	Hot Mix Asphalt
ITFT	Indirect Tensile Fatigue Test
ITSM	Indirect Tensile Stiffness Modulus
LCPC	Laboratoire Central des Ponts et Chaussees
LVDT	Linear Variable Differential Transducer
LWT	Loaded Wheel Tracking
MATTA	Material Testing Apparatus
NAPA	National Asphalt Pavement Association
OAC	Optimum Asphalt Content
PG	Performance Grade
SHRP	Strategic Highway Research Program
SMA	Stone Mastic Asphalt

SSD	Saturated Surface Dry
TMD	Theoretical Maximum Density
TRB	Transportation Research Board
UCB	University of California Berkeley
UPM	Universiti Putra Malaysia
UTM	Universal Testing Machine
VFA	Voids Filled with Asphalt
VMA	Voids in Mineral Aggregates
VTM	Voids in Total Mix
$\sigma_{x,max}$	Maximum Tensile Stress
ε_T	Initial Tensile Strain
R^2	Coefficient of Determination
s	Sample Standard Deviation
$\overline{x}$	Sample Average