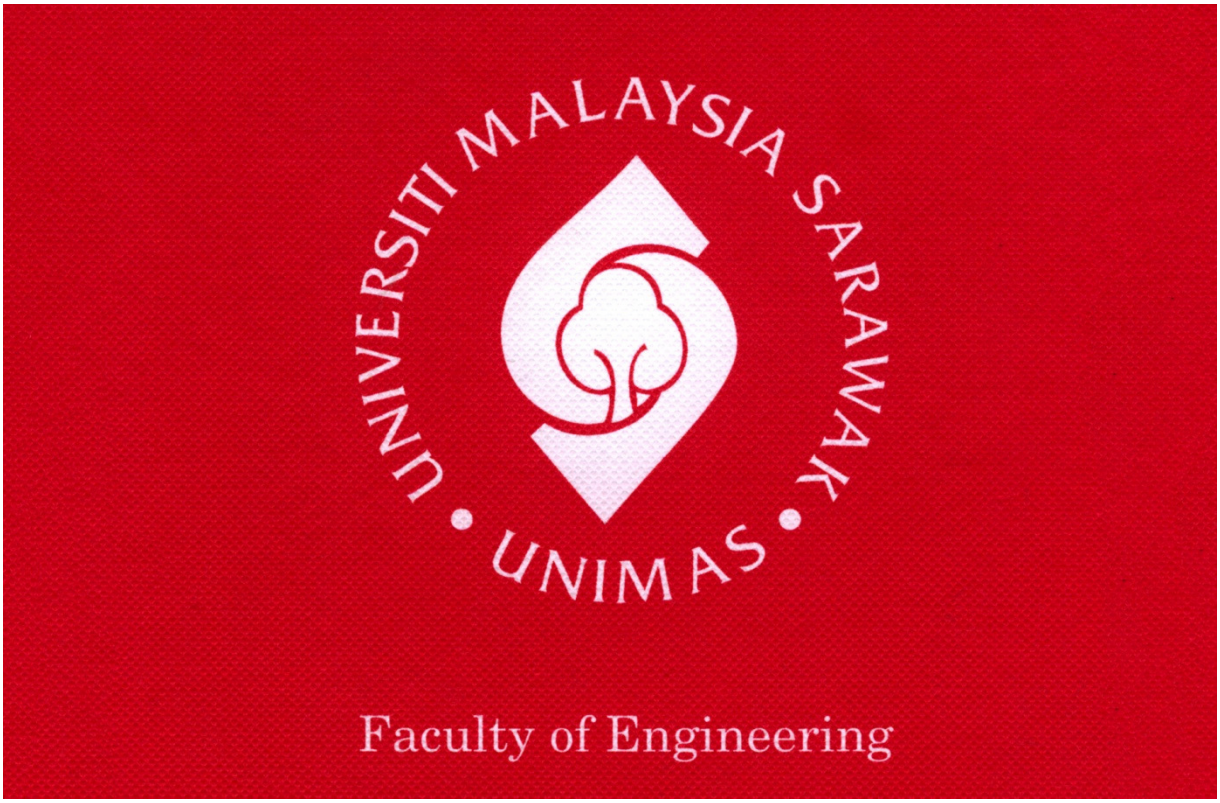

PROPERTIES OF MODIFIED BITUMEN IN HOT MIX ASPHALT USING LOCAL CRUMB RUBBER

Lim Min Khiong

Master of Engineering (Civil)

2014

UNIVERSITI MALAYSIA SARAWAK

Grade: _____

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Final Year Project Report ☐

Masters ☑

PhD ☐

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Professor MD. Abdul Mannan
(Supervisor)

26th August 2014
Date

PROPERTIES OF MODIFIED BITUMEN IN HOT MIX ASPHALT USING LOCAL CRUMB RUBBER

LIM MIN KHIONG

A Thesis submitted to

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ABSTRACT

This thesis presents a study of laboratory evaluation on the properties of modified bitumen in Hot Mix Asphalt (HMA) using local crumb rubber with the aim of partially replacing bituminous binder as well as improving the binder's properties. In the study, fine crumb rubber ranging of 0.3mm to 0.6mm taken from waste tires was added into bituminous binder using the *wet process*. The crumb rubber content of 5%, 10% 15% and 19% of weight of bitumen were added to virgin binder as modified specimens while unmodified bitumen shall be used as control samples. The crumb rubber modified binder specimens were examined by the penetration test and softening test to define the changes in terms of their physical properties prior to mix with graded aggregates to determine the volumetric properties such as Voids in Total Mix (VIM), Voids in Mineral Aggregate (VMA) and Voids Filled with Bitumen) VFB. Apart from that the Marshall Stability, Marshall Flow and Stiffness shall be determined. Two HMA aggregate mixes were being considered in this study, namely AC 14 (dense graded) and SMA 14 (gap graded). The outcome indicated that the modified binder posed a higher viscosity and temperature resistant while the increase of crumb rubber content lead to the increase in terms of the performance of HMA characteristic especially the Marshall Stability for both HMA mixes.

ABSTRAK

Tesis ini membincangkan kajian penilaian makmal ke atas sifat-sifat bitumen diubahsuai Hot Mix Asphalt (HMA) menggunakan getah remah tempatan dengan tujuan untuk menggantikan sebahagian pengikat bitumen serta memperbaiki sifat-sifat pengikat itu. Dalam kajian itu, serdak getah halus yang terdiri daripada 0.3mm hingga 0.6mm dari tayar terpakai ditambah ke dalam bahan pengikat bitumen menggunakan Proses Basah (Wet Process). Dua HMA agregat campuran telah dipertimbangkan dalam kajian ini, iaitu AC 14 (bergred tumpat) dan SMA 14 (jurang gred). Kandungan remah getah sebanyak 5%, 10% 15% dan 19% daripada keberatan bitumen ditambah kepada pengikat dara sebagai spesimen diubahsuai manakala bitumen yagn tidak diubahsuai akan digunakan sebagai sampel kawalan. Remah getah yang diubahsuai pengikat spesimen telah diperiksa oleh Ujian Penembusan (Penetration Test) dan Ujian Perlembutan (Softening Test) untuk menentukan perubahan dari segi sifat-sifat fizikal mereka sebelum bercampur dengan agregat mengikut gred bagi menentukan sifat-sifat isipadu seperti Lompang dalam Jumlah Mix (VIM), Lompang dalam Agregat Mineral (VMA) dan Lompang Dipenuhi dengan Bitumen (VFB). Selain itu Kestabilan Marshall, Marshall Aliran dan Kekukuhan juga telah ditentukan. Hasilnya menunjukkan bahawa pengikat yang diubah suai yang ditimbulkan kelikatan yang lebih tinggi dan suhu tahan manakala peningkatan sebanyak remah getah utama kandungan peningkatan dari segi prestasi terutamanya HMA ciri Kestabilan Marshall untuk kedua-dua campuran HMA.

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LIST OF ABBREVIATIONS

ABBREVIATION		TITLE
AC 14	-	Dense Graded Asphalt Concrete for Wearing (Max aggregate size 14)
ASTM	-	American Society for Testing and Materials
CRM	-	Crumb Rubber Modifier
DANCED	-	Danish Cooperation for Environment and Development
HMA	-	Hot Mastic Asphalt
JKR	-	Jabatan Kerja Raya
NREB	-	Sarawak Natural Resources and Environment Board
SMA 14	-	Gap Graded Asphalt Concrete for Wearing (Max aggregate size 14)
VTM	-	Voids in Total Mix
VMA	-	Voids in the Mineral Aggregate
VFB	-	Voids Filled with Bitumen

CHAPTER 1

INTRODUCTION

1.1 Background

Ever since concerns on environment pollution due to waste material being raised, human have been looking into innovative solutions where a specific material can be reused or recycle in order to reduce its environmental impact. Scrap tires are unquestionably one of the wastes which formed part of environmental issue in Sarawak over the year. Although there are companies collecting scrap tires and re-processed them in order to obtain the fibre and metal for varies purposes, the vast majority of a tire composition (the rubber) is still being made redundant. With the rapid increase of vehicle on the road today due to economic growth, it is necessary to construct a more durable and sustainable roads.

Crumb rubber is the commodity left during the re-processing of scrap tires, consisted of natural and synthetic rubber. Although in Malaysia, the usage of crumb rubber in modified asphaltic pavement is relatively uncommon, the U.S.A has started the use of it back in 1950 (Mashaan et al.; 2012), and have since then being widely implemented across the states of U.S.A.

Thus, in view of a more environmental friendly and sustainable engineering perspective, there will be a necessity to conduct review and study on the application of crumb rubber in HMA particularly in Sarawak with its unique local resources such as aggregates and bituminous material.

1.2 Problem Statement

According to a survey conducted by the Sarawak Natural Resources and Environment Board (NREB) in corporate with the Danish Cooperation for Environment and Development (DANCED) back in 2001, annual production of scrap tires reached to a total of 150,000 units (Anonymous; 2001). With the rapid increase of vehicle today, it is certain to say that the amount of scrap tires will increase proportionally. Additionally, the State Government of Sarawak has an environmental programme to collect, manage, and recycled scrap tires throughout Sarawak via a waste tire storage and recycling centre as well as deports state wide as part of its collection network.

Companies collecting scrap tires have been setup in bid to ease the problem of handling scrap tires in recent years. The main purpose is to retrieve the fibre and steel which contained in a tire unit which is only a minor part of a tire composition. The rubber material which is some 75% of a tire composition is usually being used as an alternative burning material which still creates pollution problems. Furthermore, as the number of vehicles on the road increased, scrap tires disposal is becoming an environmental concern to municipals and public health authorities as sanitary

landfills will soon be unable to accommodate the stockpiles of scrap tires which are also hazard for fire and public health.

Road plays a pivotal role on our daily activities, mainly transporting passengers and goods within points. Road network in East Malaysia especially the Trans-Borneo trunk road is the major route that connects not only cities and small towns throughout Sarawak but also connects Sarawak, and Sabah via Brunei, which covers a total length of approximately 2,000km. The road condition deteriorated rapidly due to its high and heavy usage mainly used by heavy trucks and buses delivering material goods and passenger between cities. Millions of Ringgit has been spent annually on the maintenance and upgrading the road for the safety of the road users. Therefore application of high durability pavement is urgently required in order to slowdown deterioration.

Researchers have been conducted in finding alternative material to be used as a modifier in asphalt mixes for the purpose of improving its properties, the crumb rubber is among one of the alternatives. The application of crumb rubber in hot mix asphalt has been long established in advanced countries, most notably the U.S.A as they aimed to tackle the amount of scrap tires every year, without compromising the quality of road but improving it instead. To date, the U.S.A is the leading country on crumb rubber modified asphalt pavement technology.

However in Malaysia, this technology is less establish and uncommon in the road construction industry. According to Hasan Norhidayah Binti Abdul (2007), road construction in Malaysia using crumb rubber as modifying agent in HMA is not significant enough. Hence there is a need to conduct research to evaluate the

performance of modified HMA using crumb rubber based on Malaysia road conditions. Aiming of enhancing the road durability thus reducing pollution and environmental problem caused over the years in Malaysia, especially Sarawak region.

1.3 Significant of Study

Conclusion shall be drawn out as to whether a modified HMA is better or worse, based on the results comparison between the modified and unmodified sample prepared, for respective grade of aggregate asphalt.

This shall provide an opportunity to overcome scrap tires problems as well as future improvement of asphalt pavement in Sarawak where lives of road user are furthered safeguard.

1.4 Objective of Study

The aim of this study is to carry out in depth analysis ensuring the addition of crumb rubber as modifier into the HMA complies with the required performance of pavement mix based on JKR standard. To achieve this, batches of samples with different proportion of crumb rubber will be added into the current design mix. These modified samples will then be compared against the unmodified samples. Specifically the objectives of this research is to evaluate performance of crumb rubber modified HMA mixes compare to conventional asphalt mixes in terms of

volumetric properties such as Void in the Mix (VIM), Void in the Mineral Aggregate (VMA) and Void Filled with Asphalt (VFB). Hence the objectives as shown below.

i. To study the penetration test of the binders
ii. To study the softening point of the binders
iii. To study the Marshall test of flow and stability of the specimens

1.5 Scope of Work

All specimens having the nominal 6% of bitumen to total weight of mix. 3 samples of respective 0%, 5%, 10%, 15%, 20% crumb rubber size of containing 300µm up to 600µm of the asphalt binder weight will be prepared using the wet process in order to study their respective penetration grade and softening point.

As for the Marshall flow and stability tests, two major types of samples will be prepared, namely Gap Graded type (SMA 14 – Stone Mastic Asphalt having nominal maximum aggregate size of 14mm) and Dense Graded type (AC 14 – Asphaltic Cement having nominal maximum aggregate size of 14mm). These specimens to be prepared in accordance to JKR's Standard Specifications for road works (JKR/SPJ/REV 2008-S4) with respective crumb rubber content specified above as binder replacement. Specimen preparations and testing shall be carried out in Civil Engineering Laboratory, UNIMAS.

CHAPTER 2

LITERITURE REVIEW

2.1 Introduction

The current chapter shall cover introductions of crumb rubbers, conventional types of hot mix asphalt (HMA) specifically the gap graded (SMA 14) and dense graded (AC14). The uses of crumb rubber in HMA as well as the types of mixing methods. The evaluations from past findings shall also be revealed in this chapter.

2.2 Scrap Tires

The issues of disposal and handling of scrap tires has became a worldwide problem from the past few decades. This is due to their rapid increase which proportionate to the increase of new vehicles registered to date. Serious environmental problems caused by improper disposal of scrap tires as shown as Figure 2.1 such as burning, land fillings etc. These have lead to the innovations of reuse/ recycling scrap tire in various fields, mainly rubber and plastic blends, automotive parts, landscaping, running tracks and playground surfaces as shown as Figure 2.2.

Figure 2.1 – Stockpiling of Scrap Tires

(I) Running Track

(II) Playground Surface

Figure 2.2– Main Uses of Scrap Tires

2.3 Crumb Rubber

Crumb rubber can be extracted from scrap tires by means of semi mechanism grinding or fully mechanism namely ambient grinding and the cryogenic process. All with the ability to shred scrap tire and ensuring the crumb rubber extracted is free of fibre and steel. To produced rubber particles that is graded and can be found in variety sizes and shapes. The crumb rubber is described or measured by the mesh screen or sieve size through which it passes during the production process (Mashaan et al.; 2012).

2.3.1 Semi Mechanism Grinding

Normally used during re-grooving used tires where the worn tread is removed using the means of grinding machines as shown as Figure 2.3 below and replace with new tread. This process only removed the unused part of a tire which is the surface rather than the entire tire. This method can produce similar particle size as per the mechanism methods.

Figure 2.3 – Semi Grinding Process