EFFECT OF MODIFIED SASOBIT ON PERFORMANCE ASPHALT MIXTURE

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To my beloved parents, supervisor (Dr. Ramadhansyah Putra Jaya) and friends for their help and never ending care and support. Thank you very much and I really appreciate all of you in my llife.

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ABSTRACT

Previous researched had shown that modified bitumen has the ability to offer improved performance over conventional bitumen. Due to the increasing number of traffic loads and volume, used of conventional bitumen is not enough to prevent the pavement from deterioration. Nowadays, modified asphalt technology is used by researcher and manufacture to improve the performance of asphalt pavement. This research presents a performance of asphalt pavement using Sasobit as an additive. In this study, the percentages of Sasobit were varied from 0%, 2.5%, 5.0%, 7.5% and 10%. The aggregate gradation that considered in this study is dense graded (asphaltic concrete with 14 mm nominal maximum aggregate size – AC14). The tests that conducted were bitumen penetration, softening point, Marshall mix design and Cantabro test. The result shows that when amount of Sasobit increases, the penetration was decreased and softening point increased. The performance of asphalt pavement was significantly affected with the addition of Sasobit. Sasobit modified mixes were found to improve both durability of the asphalt pavement and its deformation resistance. In this study, the optimum Sasobit content was found 2.5%.

ABSTRAK

Kajian sebelumnya menunjukkkan bahawa bitumen yang diubahsuai mampu untuk meningkatkan prestasi yang lebih baik berbanding dengan bitumen konvensional. Disebabkan oleh peningkatan jumlah trafik and bebannya, bitumen konversional yang digunakan tidak mampu untuk menggelakkan dari berlakunya kerosakkan pada turapan. Kini, teknologi asfalt telah diubahsuai dan digunakan oleh penyelidik dan pengeluar untuk meningkatkan prestasi turapan asfalt. Kajian ini menunjukkkan prestasi turapan asfalt menggunakan Sasobit sebagai bahan tambahan. Dalam kajian ini, peratusan Sasobit yang berbeza digunakan iaitu dari 0%, 2.5%, 5.0%, 7.5% dan 10%. Penggredan agregat yang dipertimbangkan dalam kajian ini adalah agregat tumpat (konkrit asfalt dengan 14mm maksimum nominal saiz agregat –AC14). Ujian – ujian yang dijalankan adalah ujikaji penusukan, titik lembut, rekabentuk campuran Marshall dan ujikaji Cantabro. Hasil kajian menunjukkkan bahawa apabila kandungan Sasobit bertambah, nilai tusukan menurun dan nilai titik lembut meningkat. Penambahan kandungan Sasobit telah memberi kesan kepada prestasi turapan asfalt. Campuran yang diubahusai dengan Sasobit didapati meningkatkan ketahanan dan rintangan terhadap perubahan bentuk turapan asfalt. Dalam kajian ini, kandungan optimum bagi Sasobit adalah 2.5%.

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LIST OF ABBREVIATIONS

AASTHO	-	American Association of State Highway and Transportation Officials
AC	-	Asphalt Concrete
AIV	-	Aggregate Impact Value
ASTM	-	American Society for Testing and Materials
BS EN	-	British Standard European
CRAM	-	Contained Rock Asphalt Mat
EVA	-	Ethylene Vinyl Acetate
HMA	-	Hot Mix Asphalt
JKR	-	Jabatan Kerja Raya
PI	-	Penetration Index
SG	-	Specific Gravity
SBS	-	Styrene-Butadiene-Styrene
TMD	-	Theoretical Maximum Density
VFB	-	Voids Filled with Bitumen
VMA	-	Voids in Mineral Aggregate
VTM	-	Voids in Total Mix
WMA	-	Warm Mix Asphalt

LIST OF SYMBOL

δ	-	recoverable horizontal deformation
°C	-	degree Celsius
°F	-	degree Fahrenheit
G_b	-	specific gravity of asphalt
G_{eff}	-	effective specific gravity of aggregate
G_{mm}	-	maximum specific gravity of mix
G_{sa}	-	apparent specific gravity
G_{sb}	-	bulk specific gravity
G_{ssd}	-	bulk SSD specific gravity
M_r	-	resilient modulus
N	-	stability

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Road has played an important role in the trade and transportation system throughout the world, and it become rapid increase in the pavement infrastructure development in Malaysia. 95 % of the roads in Malaysia used asphalt pavement and the rest consist of concrete pavement and concrete block pavement. A road pavement is a structure consisting of superimposed layers of processed materials above the natural soil sub-grade, whose primary function is to distribute the applied vehicle loads to the sub-grade.

Over the years, road structures have deteriorated more rapidly than expected due to increases in traffic volume, axle loading and tyre pressure and insufficient degree of maintenance. The pavement structure should be able to provide a surface of acceptable riding quality, adequate skid resistance, favourable light reflecting characteristics, and low noise pollution. The ultimate aim is to ensure that the transmitted stresses due to wheel load are sufficiently reduced, so that they will not exceed bearing capacity of the sub-grade. There are two main types of pavement which are flexible pavement and rigid pavement. This study will focus on flexible pavement.

Flexible pavement is defined as those pavements which reflect the deformation of sub-grade and the subsequent layers to the surface. Flexible, usually asphalt, is laid with no reinforcement or with specialized fabric reinforcement that permits limited flow or repositioning of the roadbed under ground changes. The design of flexible pavement is based on load distributing characteristic of the component layers. The black top pavement including water and gravel bound macadam fall in this category. Flexible pavement on the whole has low or negligible flexible strength flexible in their structural action. The flexible pavement layers transmit the vertical or compressive stresses to the lower layers by grain transfer through contact points of granular structure. The vertical compressive stress is maximum on the pavement surface directly under the wheel load and is equal to contact pressure under the wheels. Due to the ability to distribute the stress to large areas in the shape of truncated cone the stresses get decreased in the lower layer. As such the flexible pavement may be constructed in a number of layers and the top layer has to be strongest as the highest compressive stresses. To be sustained by this layer, in addition to wear and tear, the lower layer have to take up only lesser magnitude of stress as there is no direct wearing action die to traffic loads, therefore inferior material with lower cast can be used in the lower layers.

The following types of construction have been used in flexible pavement: (Mathew and Krishna, 2006)

i. Conventional layered flexible pavement
   - Layered systems with high quality expensive materials are placed in the top where stresses are high, and low quality cheap materials are placed in lower layers.

ii. Full

- Depth asphalt pavement
- Constructed by placing bituminous layers directly on the soil sub-grade. This is more suitable when there is high traffic and local materials are not available.

iii. Contained rock asphalt mat (CRAM)

- Constructed by placing dense or open graded aggregate layers in between two asphalt layers. Modified dense graded asphalt concrete is placed above the sub-grade will significantly reduce the vertical compressive strain on soil sub-grade and protect from surface water.

Pavements form the basic supporting structure in highway transportation. Each layer of pavement has a multitude of functions to perform which has to be duly considered during the design process. Different types of pavements can be adopted depending upon the traffic requirements. Improper design of pavements leads to early failure of pavements affecting the riding quality also. In order to minimize the deterioration and increase the service life of the designed road, the bituminous layers should be improved with regard to performance properties, such as resistance to permanent deformation, fatigue, wear, stripping and aging.

Recently, the substitution of industrial material as a modify asphalt properties has been taken into consideration, in order to reduce life cycle costs and obtain environmental benefits. This study will investigate the effect of using modified bitumen as an addictive to improve the performance of asphalt mixture. The use of Sasobit in asphalt paving can be utilised as a solution to the pavement deterioration problems.

1.2 Problem Statement

Flexible pavements are always prone to various distresses during its service life caused by loading and weather-induced stresses. High temperature rutting and low temperature cracking are instances of these distresses, the formation of which are known to be highly dependent on performance of the bitumen of the asphalt mixtures (Tasdemir, 2009). The fatigue cracking of flexible pavement is due to horizontal tensile strain at the bottom of the asphaltic concrete. Rutting occurs only on flexible pavement as indicated by permanent deformation or rut depth along wheel load path. Thermal cracking includes both low-temperature cracking and thermal fatigue cracking.

Currently, modified technology is used to improve its physical properties, performance and durability. Modified asphalt offers improvements in mitigation of pavement distress and reduced life cycle costs when compare to unmodified asphalt (Johnston and Gayle, 2009). Overall, the benefits of modified asphalt can be summarized as follows (Johnston and Gayle, 2009) and (Donald, 1986)

- More resistant to rutting and thermal cracking
- More resistant to flushing or bleeding
- Increase in traffic-induced stress resistance (fatigue cracking)
- Increase in stone retention
- Faster setting (minimizes land closures and traffic delay)
- Longer life-cycle with same equivalent cost

1.3 Aims and Objectives of Study

The aim of this study was to evaluate the effect of using Sasobit on asphalt mixture. In order to achieve this aim, the studies were carried out based on the following objectives:

i. To investigate the effect of using different levels of Sasobit on asphalt concrete AC14.
ii. To determine the optimum application rate of Sasobit.
iii. To study the comparison between conventional asphalt mixture and modified asphalt mixture in terms of their performance.

1.4 Scope of Study

The effect of using Sasobit on asphalt pavement was investigated in this study. The result was compared between modified and conventional asphalt pavement. In order to successfully achieve the objectives as stated, the scope is limited to:-

i. Different percentages of Sasobit (0%, 2.5%, 5%, 7.5% and 10%) by weight of bitumen were used.
ii. The optimum binder and Sasobit content of asphalt pavements were designed in accordance with Marshall mix design.
iii. Type of aggregate gradation would use is dense graded.
iv. Nominal maximum aggregate size use for asphalt pavement is AC14 with bitumen type is PEN 60/70.

1.5 Importance of Study

The properties of bitumen are important to ensure satisfactory long term performance, stability and elasticity when designing asphaltic layer. Since bitumen is a viscoelastic material, its properties are very sensitive to temperature as well as to the rate of loading. With respect to temperature, the most frequent problems of road pavement are rutting, fatigue cracking and thermal cracking like had been mentioned above. Besides, bitumen viscosity is a function of its temperature.

There are relationship between the characteristics of bitumen and its field performance. These properties are essential in order to understand effects such as bitumen modification on pavement performance. The properties constitute useful tools to analyse the influence of different concentration Sasobit. The Sasobit modified bitumen properties also can be correlated to its thermal cracking resistance of the pavement.

The identification of chemical and physical properties of bitumen before and after modification is important to determine the changes caused by the Sasobit on the Hot Mix Asphalt (HMA) performance. It is essential to ensure that the Sasobit does not affect much on the bitumen bind mechanisms with the aggregate particles.

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