EVALUATION OF STONE MASTIC ASPHALT USING PALM OIL FUEL ASH AS FILLER MATERIAL

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"Dedicated to my beloved mother,

Napisah Jusoh and father, Kamaluddin Md. Noh

My sisters, Noor Aizam, Noor Adeek, Intan Baiduri and Norlia

My brothers, Ahmad Azwan, Mohd. Kamarul Hafiz, Mohd Safari and Luqman

My nephew, Mohd Afiq Ruzaini

My sweeties nieces, Nur Fatin Nadia and Putri widat Khairina

and to very special person, Mohd Faizal Abd. Rahman

for their love, support and patience are awesome"

I Love u all very much.....Thank you

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ABSTRACT

This paper presents a study of laboratory evaluation on the performance of Stone Mastic Asphalt (SMA) using Palm Oil Fuel Ash (POFA) as filler material. POFA produced by burning palm fibre and shell which is generally used as boiler fuel to produce steam for electricity generation in the mill. POFA is one of the materials identified to have a potential of becoming an alternative filler material in SMA mixes. In this project, a small portion of POFA (passing 75μm) was used to modify asphalt mixtures. POFA was incorporated into asphalt mixes by using dry process method which refers to technologies that mix POFA with the aggregate prior to mixing it with asphalt binder. The aggregate gradations use in this study is gap graded (stone mastic asphalt with 14mm nominal maximum aggregate size-SMA14). The percentage of POFA added was varied from 0 to 7 % (2% hydrated lime) by weight of the total aggregate which is 0 to 100% by weight of the filler content. Samples was prepared and compacted using Marshall Method. Several performance indicators of mixes was evaluated using laboratory work were moisture induced damage/stripping resistant and Marshall volumetric properties. The performance results of modified asphalt mixes were compared to conventional asphalt mixes (unmodified samples). Based on the results, the performance of HMA mixes such as stability, flow and stiffness was significantly affected with the addition of POFA. The results suggest that 50% POFA by weight of filler content is the optimum value.

ABSTRAK

Kajian ini dijalankan untuk menilai tahap prestasi ‘Stone Mastic Asphalt’ (SMA) yang ditambah abu kelapa sawit (POFA) sebagai bahan pengisi. POFA terhasil dari proses pembakaran sabut dan tempurung kelapa sawit yang pada kebiasaannya digunakan sebagai bahan bakar dandang untuk menghasilkan wap bagi menjana sistem elektrik di dalam kilang memproses minyak kelapa sawit. POFA adalah salah satu bahan yang dikenalpasti mempunyai potensi untuk dijadikan bahan pengisi alternatif di dalam campuran SMA. Di dalam kajian ini, POFA (melepasi saiz ayak 75μm) digunakan dalam kuantiti yang sedikit untuk mengubahsuai campuran SMA. POFA akan dimasukkan ke dalam campuran asfalt dengan menggunakan kaedah proses kering (dry process) di mana POFA dicampurkan ke dalam aggreget sebelum diadun dengan bitumen. Campuran aggregate yang akan digunakan di dalam kajian ini ialah *‘gap graded’* (Stone mastic asphalt dengan 14mm saiz nominal maksimum – SMA 14). Peratus POFA yang digunakan di dalam kajian ini divariasikan dari 0 hingga 7% (2% hydrated lime) dari berat keseluruhan aggreget di mana 0 hingga 100% dari berat keseluruhan bahan pengisi. Sampel disediakan dan dipadatkan dengan menggunakan kaedah Marshall. Beberapa ujian prestasi campuran yang dijalankan ialah ujian kerosakan akibat lembapan (moisture induced damage) dan ciri-ciri isipadu Marshall. Keputusan prestasi campuran yang telah diubahsuai dibandingkan dengan campuran yang tidak diubahsuai (tanpa POFA). Berdasarkan dari keputusan yang diperolehi, dapat diperhatikan bahawa POFA memberi kesan yang ketara terhadap prestasi campuran asfalt terutamanya kestabilan, aliran dan kekukuhan. Keputusan menunjukkan 50% POFA dari kandungan pengisi adalah nilai optimum yang boleh digunakan.

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LIST OF ABBREVIATIONS/SYMBOLS

POFA	Palm Oil Fuel Ash
HMA	Hot Mix Asphalt
SMA	Stone Mastic Asphalt
NAPA	National Asphalt Pavement Association
TSR	Tensile Strength Ratio
SMA 14	Stone Mastic Asphalt with Nominal Maximum Aggregate Size of 14mm
JKR	Jabatan Kerja Raya
UTM	Universiti Teknologi Malaysia
AAPA	Australia Asphalt Pavement Association
DG	Dense Graded
ASTM	American Society for Testing and Materials
US	United State
VMA	Voids in Mineral Aggregate
VFA	Voids Filled with Asphalt
VTM	Voids in Total Mix
AASHTO	American Association of State Highway and Transportation Officials
PG	Performance Grade
OBC	Optimum Bitumen Content
MRP	Malaysia Rock Product
TMD	Theoretical Maximum Density
SSD	Saturated-Surface-Dry
LAA	Los Angeles Abrasion

ITS	Indirect Tensile Strength
SiO_2	Silicon Dioxide
AlO_3	Aluminium Oxide
FeO_3	Ferric Oxide
CaO	Calcium Oxide
MgO	Magnesium Oxide
SO_3	Sulphur Trioxide
LOI	Loss on Ignition
OPC	Ordinary Portland Cement
HL	Hydrated Lime
G_{sb}	Combined bulk specific gravity of total aggregate
G_{mb}	Bulk specific gravity of compacted mix
G_{mm}	Theoretical maximum density
AC	Asphalt Cement

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CHAPTER I

INTRODUCTION

1.1 Background

Over the last few decades, the Malaysian palm oil industry has grown to become a very important agriculture-based industry, where the country is today the world's leading producer and exporter of palm oil (Yusoff, 2004). At the same time, there are lot of researches has been conducted in order to investigate other alternative material as a filler/modifier in asphalt mixes. The concept of modifying asphalt mixes is not new. In fact, since years ago there have been numerous efforts to modify asphalt mixes in order to get a better performance and quality of hot asphalt mixes.

However, in Malaysia, the application of ash as filler in hot mix asphalt is not significant enough. This is due to the less number of researches being conducted in evaluating the potential of ash as an alternative material to improve the performance of asphalt mixes according to Malaysian condition. Hence, there is a need to conduct a detailed study on the performance of Malaysian hot mix asphalt using Palm Oil Fuel Ash (POFA) as a modifier/filler. Recycling of the waste product will not only have environmental significance, but it also has potential to be cost effective and improve performance of new flexible pavements as compared to conventional hot

mix asphalt. Besides, if the enhanced characteristics of asphalt pavement using POFA as filler are significant, it could be a potential for POFA to be used as a modifier in HMA mixes.

It is necessary to address the engineering properties, environmental and economic concerns before using these materials in order to achieve sustainable development. SMA containing a waste material should perform equal or better than conventional SMA. In addition, it should be also noted in environmentally issues both for the initial construction and future recyclability.

The type of aggregate gradation used in this study was gap graded gradation which is stone mastic asphalt (SMA14). Stone mastic asphalt is a tough, stable, rut-resistant mixture that relies on stone-to-stone contact to provide strength and a rich mortar binder to provide durability. The estimated 20-25% increase in cost is more than offset by the increase in life expectancy of the mix, primarily through the decreased rutting and increased durability. SMA is considered to be a premium mix by several state Departments of Transportation for use in areas where high-volume traffic conditions exist and frequent maintenance is costly (NAPA, 2002).

In this study, the investigation was conducted by using binder PG 76 on a range of gap graded (SMA 14) containing 0% (control), 25%, 50%, 75% and 100% Palm Oil Fuel Ash (POFA) by the total weight of the filler content. The performance of modified and conventional SMA were compared through laboratory tests on the mechanical properties such as stability, flow, stiffness and resistance to moisture-induced damage in order to investigate the influence of utilisation of Palm Oil Fuel Ash (POFA) as filler material in hot mix asphalt mixtures.

1.2 Problem Statement

Within the last few years, environmental issues are increasingly becoming more important in Malaysia and all over the world. The ash produced by burning palm fibre and shell is considered to be a waste product and the disposal of which poses enormous problems. In many develop countries, due to the increasing cost of materials and the continuous reduction of natural resources, the use of waste material is a potential alternative in the construction industry. Waste material likes Palm Oil Fuel Ash (POFA), when properly processed, have shown to be effective as construction materials and readily meet the design specifications (Mannan and Ganapathy, 2002). This will have the double advantage of reduction in the cost of construction material and also as a means of disposal of waste. In this study, the feasibility of using POFA as filler material will be evaluated.

On the other hand, the increases of traffic loading and number of heavy vehicles caused pavements tend to fail prematurely either structurally or functionally even though they have been designed to last longer. Repeated application of traffic loads can cause structural damage to asphalt pavements in the forms of fatigue cracking of asphalt layer, rutting along the wheel tracks and loss of adherent between aggregate and asphalt cement and cause stripping. These kinds of damages quite worst especially in hot climatic conditions like Malaysia. Government has spent millions of ringgit to repair and maintain roads in this country. Development of modified asphalt mixes has been explored over the past few decades in order to improve the performance of pavements mixes. Utilisations of POFA as modifier material in asphalt mix have not been firmly established and explored. Thus, there is a need to conduct a study to evaluate the performance of HMA after being modified using Palm Oil Fuel Ash (POFA) according to Malaysian condition. In this study, resistance of compacted bituminous mixture to moisture-induced damage using POFA was investigated.

1.3 Objectives of the Study

This study was conducted to achieve several objectives. The objectives of this study are:

i. To evaluate the performance of Marshall properties of hot mix asphalt mixes with POFA as filler.

ii. To investigate the stripping potential due to moisture induced damage of the asphalt mixes using POFA as filler and compared the tensile strength and Tensile Strength Ratio (TSR) values.

1.4 Scope of the Study

The scope of this study focused on the effect of utilising Palm Oil Fuel Ash (POFA) as filler material in hot mix asphalt. The gap graded gradation (SMA14) was used as typical type of aggregate gradation in the mixture.

Each sample of SMA mixes was compacted as stipulated in the JKR specifications (JKR/SPJ/2007) using Marshall design procedures. The stone mastic asphalt mixes was modified using Palm Oil Fuel Ash (POFA). The size of POFA that was used in the asphalt mixes is passing sieve size 75µm. The numbers of samples prepared were divided into five categories where the percentage of POFA used in this mixes varied from 0 to 100% by the total weight of the filler content. These categories include unmodified samples, samples added with 25% of POFA, samples added with 50% of POFA, samples added with 75% of POFA and samples added with 100% of POFA in order to identify which mix that meets the desired performances.

The addition of POFA in the mixes was used the method of 'dry process' where ash is added as part of the aggregate component first before it was blended with the asphalt cement. The POFA was replaced a dust composition in the mixes and reacted as filler in the mixes to improve properties of the mixture. Hydrated lime was used in this study as stabilising agent. Laboratory stability and flow test (Marshall) and indirect tensile strength test were performed on the mix design that meets the best performances for volumetric properties and stripping resistance (moisture-induced damage) measurements. The entire test was conducted at Highway and Transportation Laboratory, UTM, Skudai, Johor, Malaysia.

1.5 Significant of the Study

From the result obtained in the end of this study, it can be proposed to consider utilisation of POFA in stone mastic asphalt as filler material and to improve resistance to moisture-induced damage in order to provide pavement with better durability and strength by minimizing the distresses occurred in HMA pavement. Hence, the road pavement will provide a safe and smooth riding for vehicular travel. In addition, the utilisation of POFA can also be proposed to solve waste problem in order to get sustainable development or use it as an alternative material in pavement construction. Based on the findings, it can be proposed that utilisation of POFA in the mixture should be taken into consideration for further studies in the future. Utilisation of POFA in the pavement design is not well establish and explored. Hence, contractors may have problem using POFA in the SMA mix cause by lack of experience since this mix is considered as new mix for road pavement compared to standard asphaltic concrete. So, from this study, the information obtained would provide valuable information to agencies who desire to construct SMA pavement using Palm Oil Fuel Ash (POFA) as filler material.

iv. Utilisation of POFA can reduce environment problem by using it as filler material in HMA especially SMA and reduced the cost of treatment and disposal of the waste.

Utilisation of POFA in HMA does not have any apparent effect to the mixes. Therefore, it can be used or recycled rather than disposed in the landfill without any purpose.

5.2 Recommendations

It is recommended that further studies be conducted on a variety of gradation type such as dense graded and porous graded. Different percentage of POFA use can be investigated to determine the effect to the mixture. Instead of moisture induced damage resistance, other pavement deterioration due to rutting, fatigue and aging should be studied in order to investigate the engineering properties of the mixes. Detail study should be conducted to investigate the effect of utilisation of POFA in hot mix asphalt mixture in order to provide strength and durable pavement by minimising the distress occurred in HMA pavement. Hence, the road pavement will provide a safe and smooth riding for vehicular travel. In addition, the most important effort is to compile all the results obtained from all research that are related and revised by a responsible board in order to make worth of it in improving the hot mix asphalt performance according to Malaysian condition.

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