EFFECT OF PALM OIL FUEL ASH (POFA) FINENESS ON THE PROPERTIES OF ASPHALTIC CONCRETE AC 14

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Dedicated to my parents,
my beloved wife and children
Hafsat, Khaleel & Aishat
Thanks for your prayers, sacrifices and patience……..

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ABSTRACT

The nature and amount of the fines or filler (particles smaller than 75 μm) in an asphaltic concrete mixes significantly affect its design and performance. Palm oil fuel ash (POFA) is an ash obtained from the burning of waste material generated from the production of crude palm oil which is of high quantity in Malaysia. This study therefore, evaluates the effect of the fineness of POFA on the mechanical properties of asphaltic concrete AC 14. Using 4 different categories of POFA fineness (based on 30min of grinding, 60min, 90min and 120min), a number of trial mixes were prepared using the Marshall Mix design procedure with 5% POFA to arrive at asphalt concrete mixtures that fulfil the Marshall criteria. The effects of each POFA fineness category on the stability, flow, stiffness, indirect tensile strength and cantabro loss of asphaltic concrete (AC 14) mixtures at their respective optimum binder content were evaluated. The results show that Marshall stability, flow, stiffness indirect tensile strength and cantabro loss values were generally higher when POFA is grinded than that of controlled specimens, but after some period of grinding (peak of the curve), the values diminished. Hence, grinding POFA to some extent improves the properties of asphaltic concrete. Grinding POFA for up to 60 minutes gives the optimum improvement of the properties of asphaltic concrete mixes considered in this study.

ABSTRAK

Sifat dan jumlah pengisi (bahan lebih kecil daripada 75 µm) dalam campuran konkrit asphalt akan mempengaruhi rekabentuk dan prestasi campuran. Debu daripada kelapa sawit yang dibakar (POFA) ialah abu yang didapati daripada lebihan bahan semasa pengeluaran minyak sawit mentah yang kuantitinya sangat banyak di Malaysia. Oleh itu, kajian ini menilai kesan kehalusan POFA terhadap sifat mekanikal konkrit asphalt AC14. Menggunakan 4 kategori kehalusan yang berbeza (dikisar selama 30 minit, 60 minit, 90 minit dan 120 minit), beberapa campuran percubaan disediakan menggunakan prosedur campuran Marshall dengan 5% daripada campuran itu adalah POFA untuk memenuhi kriteria campuran Marshall. Kesan daripada kehalusan POFA terhadap kestabilan, aliran, kekukuhan, kekuatan tegangan tak langsung dan kehilangan konkrit kontabro (daripada campuran AC14) pada jumlah bitumen optimum akan dinilai. Keputusan menunjukkan bahawa kestabilan, aliran, kekuatan tegangan tidak langsung, nilai kekukuhan dan kehilangan kontabro pada campuran Marshall adalah lebih tinggi apabila dicampur dengan POFA, tapi selepas beberapa ketika POFA dikisar (pada puncak lengkung) nilainya akan berkurang kembali. Jadi pengisaran POFA pada kehalusan tertentu akan meningkatkan ciri-ciri campuran konkrit asfalt. Oleh itu, dalam kajian ini pengisaran POFA sehingga 60 minit memberikan peningkatan yang optimum pada sifat konkrit asphalt.

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LIST OF SYMBOLS

A	-	Weight of oven dry sample
B	-	Weight of saturated surface dry sample
C	-	Weight of sample in water
D	-	Specimen diameter
h	-	Specimen height
P	-	Maximum load
Al_2O_3	-	Aluminium oxide
C_aO	-	Calcium oxide
CO_2	-	Carbon dioxide
Fe_2O_3	-	Ferric oxide
G_b	-	Specific Gravity of Binder
G_{mb}	-	Bulk Specific Gravity
G_{mm}	-	Maximum specific gravity
G_{se}	-	Effective specific gravity

K_2O	-	Potassium oxide
MgO	-	Magnesium oxide
NaO	-	Sodium oxide
P_b	-	Percentage of binder
SiO_2	-	Silicon dioxide
SO_2	-	Sulphur oxide
S_t	-	Indirect Tensile Strength

LIST OF ABREVATIONS

AC 14	-	Asphaltic Concrete with 14 mm Nominal Size Aggregate
AC 20	-	Asphaltic Concrete with 20 mm Nominal Size Aggregate
ASTM	-	American Society for Testing and Material
CL	-	Cantabro Loss
IDT	-	Indirect Tensile
JKR	-	Jabatan Kerja Raya
LAAV	-	Los Angeles Abrasion Value
MRP	-	Malaysia Rock Product
OAC	-	Optimum Asphalt Content
OPC	-	Ordinary Portland Cement
POFA	-	Palm Oil Fuel Ash
RAP	-	Reclaimed Asphalt Pavement
TDM	-	Theoretical Maximum Density
VFB	-	Void Filled with Bitumen
VTM	-	Void in Total Mix

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CHAPTER 1

INTRODUCTION

1.1 Background

The history of road construction dated back to the Roman roads of the 18 centuries. However, despite this long history and hence the vast experience of road construction, engineers continuer to design and construct roads that fail. These pavement failures represent serious economic lost to countries all over the word, Malaysia is not an exception. Malaysia is witnessing rapid economic development in recent years, and this has placed high performance demand on its highway infrastructure. Evidence of early pavement failures has been widely reported on Malaysian roads due to increase axle loading among other things. (Kordi, 2010). This trend has pushed the conventional design methods and construction materials to the edge. Thus the need for sustainable construction materials cannot be overemphasize.

Researchers worldwide try to develop better composites, both affordable and more resistant, road construction materials that can sustain the rapid growth in axle loading. Many different, and sometimes conflicting, performance demands are placed upon the asphalt mixtures and this makes it a complex material. Thus, the design of asphalt concrete mixes is largely a matter of selecting and proportioning the ingredient materials to optimize all desired properties in the finished paved road. Amongst the components of the asphaltic concrete mixes is the filler, which

is a fine material passing the No. 200 sieve. Better understanding of the roll of fillers on the performance of asphalt mixtures is an important new frontier in paving material research.

Fillers have only been thought to fill voids in the aggregate. However, studies indicated that the role of fillers in asphalt mixture performance is more than filling voids depending on the type used. Many studies have been carried out on effects of fillers on the behavior of asphalt mix (Asi and Assa'ad 2005, Karasahin and Terzi 2007 and Mehari 2007). Different filler materials may have different mechanical properties in the asphalt mixture. However, a thorough understanding of the effect of fine particulate fillers in asphalt binders and mixes has not been reached.

According to Muniandy et al, (2012), the main course of premature failure on pavements in Malaysia is rutting due to uncontrolled large and axle loads, increased traffic levels and tyer pressures. As the viscoelastic properties of asphalt cement is very much temperature-dependent, asphalt binder becomes viscous and displays plastic flow when subjected to loads higher than its viscosity at a higher temperature. The plastic flow occurs due to lack of internal friction between aggregate particles and use of excess asphalt binder. This has facilitated the need to enhance and improve the characteristics and the properties of existing asphalt material. The one known form of binder improvement is by means of fillers, traditionally used to improve the temperature susceptibility of asphalt by increasing asphalt binder stiffness at high service temperatures, enhances the service properties over wide range of temperature, when asphalt binders are combined with fillers, mastic is formed this mastic can be viewed as the component which glues the aggregate together and which undergoes deformation when the pavement is stressed during service.

Malaysia is one of the leading producers of crude palm oil with around 41% of the total world supply in years 2009–2010. The by-product of Palm oil production has been disposed as waste thus causing environmental problems and

health hazards. Some of the waste materials with high fuel value, such as palm oil husks and shells, can be reused as fuel to produce steam for generating electricity, which is required for extracting crude palm oil. After combustion, about 5% of palm oil fuel ash (POFA) or boiler ash is produced. POFA when properly processed has shown to be a good construction material in concrete and mortar, Altwair et al. (2011).

POFA is identified as a material that shows good potential to be used as filler in asphalt mixture. Intensive literature showed that the optimum amount of POFA as filler in asphaltic concrete mixture ranges from 3% to 7% by weight of the aggregate. Mineral filler with medium particle size has been found to improve some mechanical properties of asphaltic concrete mixtures compared to other particle size proportions.

1.2 Problem Statement

Asphaltic pavement failure is a common and recurring problem that deserved serious attention from the stake holders because of the huge economic lost and tragic loss of life involved. On the other hand, the Association of Malaysia Haulers (AMH) and truck operators want to raise the lorry load limit as similar size vehicles have been transporting heavier loads overseas. In an effort to solving the problem of early pavement damages on Malaysian roads, a lot of studies have being going on aimed at understanding the relationship between various component of asphaltic mixes so as to develop the appropriate construction materials that will meet the challenges of today's pavement performance demands.

Similarly, environmental awareness of the side effects of landfill sites is forcing Countries to develop better ways to recycle and increase usage of industrial wastes and by-products. As this will both decrease the demand for available materials and help solve many disposal problems. The use of industrial wastes and

by-products (POFA) as fillers in asphalt mixtures has benefits in not only reducing the amount of waste materials requiring disposal but can provide construction materials with significant savings over new materials. In this study, the appropriate particle size of POFA that will produce an optimized asphaltic concrete mixes will be investigated.

1.3 Aim and Objectives

The aim of this study is to evaluate the effect of POFA fineness on the mechanical properties of asphaltic concrete through the following objectives:

I. To investigate the effect of different particle size of POFA on the properties of asphaltic concrete AC 14.

II. To determine the optimum fineness of POFA for asphaltic concrete AC 14.

1.4 Scope and Limitation of the Study

The study is limited to AC 14 asphaltic concrete, with the aggregate to be obtained from Malaysia Rock Product Sdn Bhd. (MRP) at Ulu Choh, Pulai, Johor Bahru. The type of bitumen used is 80/100 penetration grade supplied by Kemaman Bitumen Company Sdn Bhd, and POFA was obtained from Pertubuhan Peladang Negeri Johor, Kahang Palm Oil Mill. The study only considered four different graining periods, 30 minutes, 60 minutes, 90 minutes and 120 minutes of POFA sample with 100% passing 75µm sieve.

The mechanical properties of asphaltic concrete considered were stability, flow, stiffness, indirect tensile strength and durability (Cantabro test), and Marshall mix design procedure was adopted. 5% POFA as replacement of mineral filler was used on all samples in dry mixture. All laboratory experiments were conducted at the Highway and Transportation Laboratory of the Faculty of Civil Engineering, University of Technology, Malaysia.

1.5 Significance of Study

Flexible pavements in Malaysia are designed for ten to fifteen years design life, but some roads may show signs of early failures especially in industrial areas because of heavy lorries (Kordi, 2010). A lot of factors contribute to the problem of early distresses on Malaysian roads, not only due to under design or insufficient construction method, but also due to over loading or because of the usage of week materials. (Bughrara, 2008) Several research efforts are being undertaking to develop better construction materials that will meet the present challenges; this study is one of them. From this study, the appropriate particle size of POFA required to produce better quality asphaltic concrete was established and recommended for future use.

More so, the commercial use of POFA in asphaltic concrete will seriously encourage the recycling of industrial wastes and by-products, and this will solve many waste disposal problems. The cost of constructing flexible pavement will be reduced because POFA costs less compared to the conventional mineral fillers like cement, lime etc. Data from this study provides valuable information to future studies, road construction agencies and other stake holders.

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