THE EFFECT OF AN ADDITION OF CRUDE PALM OIL TO THE DENSITY AND VOIDS OF ASPHALT MIX

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I hereby declare that I have checked this project and in my opinion, this project is adequate in terms of scope and quality for the award of the Bachelor Degree of Civil Engineering

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STUDENT'S DECLARATION

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

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ABSTRAK

Peningkatan dalam keperluan alam sekitar dan kos permulaan pengikat asfat yang tinggi telah menggalakkan para penyelidik mengubahsuai atau menggantikan pengikat yang lebih alternatif untuk digunakan dalam Campuran Asfat Panas. Pengubahsuaian asfat memainkan peranan penting dalam industri asfat. Untuk mencapai matlamat untuk memilih sifat pengikat yang terbaik, bahan tambah yang dipilih harus menghasilkan tindakbalas kimia dalam pengikat asfat dengan menggabungkan bahan tersebut dengan pengikat. Kenaikan kos produk petroleum menyebabkan pengubahsuaian dalam pengikat asfat semakin mahal dan sukar. Terdapat penurunan yang berterusan dalam prestasi sifat turapan asfat. Lazimnya, kerosakan jalan raya timbul akibat jumlah hujan yang tinggi seterusnya menyumbang kepada kos pemuliharaan jalan raya yang semakin meningkat. Oleh itu, lebih banyak penyelidikan perlu dilakukan untuk meningkatkan prestasi turapan asfat. Terdapat pelbagai kaedah yang digunakan untuk menghasilkan Campuran Asfat Panas untuk jalan raya berturap seperti kaedah Campuran Rekabentuk Marshall, kaedah Hveem dan yang terbaru ialah kaedah yang dipanggil sebagai Superpave. Dalam menghasilkan Campuran Asfat Panas, satu kaedah reka bentuk campuran yang merangkumi prosedur makmal perlu dijalankan untuk mengesahkan perkadaran bahan yang perlu digunakan. Kaedah Campuran Rekabentuk Marshall biasanya digunakan untuk reka bentuk Campuran Asfat Panas. Kajian ini dijalankan untuk menentukan potensi minyak kelapa sawit sebagai bahan tambahan dalam reka bentuk Campuran Asfat Panas untuk menyediakan lapisan haus dan lapisan pengikat yang mencukupi dalam jalan raya belentur. Potensi minyak sawit mentah akan ditentukan berdasarkan kebolehkerjaan, ketahanan, kestabilan dan kekuatan campuran tersebut. Kesemua ujian dijalankan di dalam makmal lebuh raya untuk mendapatkan data dan menentukan sifat Campuran Asfat Panas. Segala maklumat berkaitan prosedur, proses dan teknik yang digunakan untuk menghasilkan Campuran Asfat Panas dengan tambahan minyak sawit mentah akan dijelaskan dalam kajian ini. Segala maklumat dan garis panduan pengiraan yang terlibat dalam kaedah Campuran Rekabentuk Marshall juga ditunjukkan secara terperinci. Secara umumnya, semua keputusan harus memenuhi kehendak Jabatan Kerja Raya Malaysia (JKR).

ABSTRACT

The increasing in environmental regulations and high initial cost of asphalt binder has encouraged researchers to modify or replace the alternative binders that can be used for hot mix asphalt (HMA). Asphalt modification acts as an important role in the asphalt industry. In order to achieve the goal of refining binder properties, a chosen additive should produce an interaction within asphalt binders by combining chemically with the binder. Modification of asphalt binders is becoming gradually expensive and difficult due to rise costs of petroleum products. There has been a constant decline in the performing of asphalt pavement properties. Normally, road defect occurred due to high volume of rainfall that will contribute to high road maintenance cost. Therefore, more researches need to be carried out on how to improve the performances of asphalt pavement. There are various types of method used to produce the Hot Mix Asphalt for road pavement such as Marshall Mix Design, Hveem Method and the latest method called Superior Performing Asphalt Pavement or Superpave. While producing the HMA, a mix designs method that includes the laboratory procedures have to be conducted to validate the necessary proportion of the materials to be used. The Marshall Mix Design Method is commonly used for the design of Hot Mix Asphalt (HMA). This study was conducted to determine the potential of crude palm oil as an additive in hot mix asphalt design in order to provide the sufficient wearing course in flexible pavement. The potential of crude palm oil will be determined based on its workability, durability, stability and the strengthens. All of the tests were conducted in the highway laboratory to collect data and determine the Marshall properties of HMA. All the information which related to the procedures, process and techniques used to produce Hot Mix Asphalt with additional crude palm oil will be explained in this study. The information and guideline used to obtain and calculate all the properties of the material for HMA and criteria for the Marshall Mix Design also will be included. In general, all the results should meet the Malaysian Public Works Department.

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LIST OF SYMBOLS

M	Mass
V	Bulk volume of specimen
V_{MM}	Volume of void-less mix
V_A	Volume of air between coated aggregate particles in mix
M_{BA}	Mass of absorbed binder (within surface of aggregate particles)
V_{BA}	Volume of absorbed binder (within surface of aggregate particles)
M_{BE}	Mass of effective binder
V_{BE}	Volume of effective binder
M_B	Mass of constituent binder
V_B	Volume of constituent binder
M_G	Mass of aggregate
V_G	Bulk volume of aggregate
V_{GE}	Effective volume of aggregate
ρ	Density

LIST OF ABBREVIATIONS

HMA	Hot Mix Asphalt
CPO	Crude Palm Oil
EFB	Empty fruit bunches
PCC	Portland Cement Concrete
PWD	Public Work Department
NAPA	National Asphalt Pavement Association
ASTM	American Society for Testing and Materials Standards
AASHTO	American Association of State Highway and Transportation Officials
OAC	Optimum Asphalt Content
ACW 14	Asphaltic Concrete Wearing-14
ACB 28	Asphaltic Concrete Binder 28
AC	Asphalt content
AI	Asphalt Institute
VFA	Voids filled with asphalt
VMA	Voids in mineral aggregates
VIM	Air voids in mix
SPJ	Standard Specification for Roadwork

CHAPTER 1

INTRODUCTION

1.1 Introduction

This chapter explains the overview of the study and the purpose of this study. The chapter includes the background of the research, problem statement, objectives that are expected to be achieved, scope of the study and the significant of research.

1.2 Background of Research

The increasing in environmental regulations and high initial cost of asphalt binder has encouraged researchers to modify or replace the alternative binders that can be used for hot mix asphalt (HMA). Asphalt modification acts as an important role in the asphalt industry. In order to achieve the goal of refining binder properties, a chosen additive should produce an interaction within asphalt binders by combining chemically with the binder. The strength, stiffness, and adhesion of asphalt with aggregate must be prominently upgraded in contrast with the conventional asphalt binder to withstand the performance of the pavement (Daniel, et al., 2013). It is not surprising to observe various attempts to modify asphalt properties through the physical mixing or chemical modification (Bahia et al., 2012).

This study focuses on using crude palm oil (CPO) as possible alternative asphalt binder used in HMA. In Malaysia, crude palm oil is one of the largest suppliers in the world. Therefore, enormous quantity of crude palm oil could not be an issue to produce which is made from natural resources that can be contributed to the environmental benefits. The properties of asphalt binders are important role in the construction, maintenance and recovery of roadway to enhance the performance of pavement and improve base binder performance (Bahia et al., 2012). In addition, due to rising costs related with conventional asphalt binders, a number of low-cost asphalt modification

and effective techniques have been presented to minimize the cost and maximize the performance of conventional binders (Rubab et al., 2011). Therefore, an addition of CPO is proposed to enhance the low-temperature properties and performance of asphalt binders.

However, during the production of crude palm oil, a great amount of waste material is produced, such as empty fruit bunches (EFB), shells and palm oil fibers (husk) which is recycled as fuel to produce steam that generate electricity, which is necessary for obtaining crude palm oil. Alternatively, additive for asphalt binder predominantly is a best way to design against or to renovate pavement due to the harms such as surface defects (stripping and ravelling), structural defects (rutting, shoving and distortion) and cracking (fatigue and thermal). Crude palm oil can be stated as an alternative asphalt binder which differs from conventional asphalt in terms of strength and durability. According to the previous studies, the addition of crude palm oil to the Hot Mix Asphalt mixture performance tests showed that the mix can reduce the resistance to rutting, cracking and the stiffness of the mixtures. Furthermore, it also can increase the confrontation due to thermal cracking (Rosli, Nasir A. et al., 2014).

The purpose of additive is to improve the physical properties of an asphalt mixture which are stability, flow, density and voids content (Arahan Teknik (Jalan) 5/85. 2008). All these properties are administrated to some amount by degree of compaction, aggregate gradation, binder type and content. Moreover, these different binders have not been tested broadly and their effects for short and long term performance are not well recognized. Hence, a better understanding on the effect of oil modifiers at a primary level will benefit to better material selection and achieve optimum performance (Daniel, et al., 2013). In conjunction to this concern, we aim to determine the liability of the binder to the loading time should be low, whereas its breaking strength, permanent deformation resistance, and fatigue characteristics should be high. Moreover, modified asphalts should have at least the same bond qualities (active and passive) as conventional binders. Lastly, its maturing characteristics should be good for both laying and services (Brule, 2009).

1.3 Problem Statement

Modification of asphalt binders is gradually expensive and challenging due to highest price of petroleum products. However, it is possible to improve new engineering materials by mixing and blending various products or waste materials with the asphalt binders (Raman et al., 2015). Crude palm oils are one of the new materials that can be used as asphalt modifier to recover the low temperature properties and reduce the price of the final mixture. Therefore, there is need to investigate the effect of an addition of CPO to the maximum theoretical Specific Gravity of the asphalt mix (Gmm) and air voids by using of these products as asphalt binder modifiers based on wide understanding of their effects on and performance and composition of the materials used. A study by Daniel, et al. (2013) proposed that introduction of oils into base binder may disrupt its internal structure, which is results in changes of some rheological properties.

Although, a few researchers have investigated the effect of oil modification on the properties of asphalt binder, there is no systematic research on the fundamental mechanisms urging to this type of modification. The goal of this study is to determine the effect of an addition of crude palm oil to the density and voids of asphalt mixture and to identify if the oil can enhance the low-temperature properties and performance of asphalt binders. To investigate the appropriateness of crude palm oil as a modifier for asphalt binders. In response to this concern, we aim to investigate the mechanical, thermal and physical engineering properties of oil modified binders to attain an inclusive understanding of the effect of oil modification.

1.4 Research Objectives

The objectives of this research are summarized as follows:

1. To characterize the properties of the addition of crude palm oil in asphalt mix more accurately.
2. To explore the contribution of crude palm oil as an additive in improving the performance of asphalt binder.
3. To investigate the effect of addition of crude palm oil on asphalt binder to the void ratio of the asphalt mix.

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