

PHYSICAL AND CHEMICAL PROPERTIES OF RECYCLED BITUMEN  
INCORPORATING REJUVENATOR

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## **DEDICATION**

Dedicated to my beloved father (Alm) Abdul Wahab, my mother Amrah, and brothers Muhammad Noor Fajrin for their love, support and patience.  
Also not forgotten, thank you to all my best friends and love, for their encouragement, and support.

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Praise gratitude the I say to God Almighty, because of His blessings and mercy I can complete this final assignment. The prayer and greetings also send to the Prophet Muhammad.

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During the preparation of this final report, the author realized many shortcomings. Therefore, with all sincerity, I expect all criticism and constructive suggestions for the perfection of this final project report.

I hope this final project research report is useful for civil engineering colleagues and all interested parties.

## **ABSTRACT**

The usage of reclaimed asphalt pavement (RAP) in recycled asphalt mixture caused the bitumen to become stiffer. Additional of rejuvenator or rejuvenating agent is required to reduce the stiffness and change the properties of bitumen. Therefore, this study investigated the effect of adding rejuvenator on physical and chemical properties of aged bitumen. The relationship between physical and chemical properties were also evaluated in this study. The physical property tests conducted were Penetration test, Softening Point (SP) test, Viscosity and Bending Beam Rheometer (BBR). The chemical property tests were Fourier Transform Infra-Red (FTIR) and Gas Chromatography-mass Spectroscopy (GC-MS). The oil-based rejuvenator namely cecabase was added with the variation of 0.3%, 0.5%, 0.7%, and 1.0% from the weight of bitumen. The result shows that the penetration increase and viscosity decrease with the additional cecabase. The SP and BBR tests show the inconsistent pattern. Through the FTIR test, the sulfoxide, carbonyl, and aromatic index ratio decrease while the aliphatic index increase with the increment of rejuvenator. This results proved that the aged bitumen undergo the rejuvenating process. The GC-MS test result shows that 0.7% rejuvenator content gave the same chemical components to bitumen control. The relationship between both properties shows that change in physical properties due to additional rejuvenator did not necessarily change the chemical properties of the respective bitumen.

## ABSTRAK

Penggunaan turapan asfal tebusguna (RAP) di dalam campuran asfal kitar semula menyebabkan bitumen menjadi keras. Penambahan ejen pemulihan diperlukan untuk mengurangkan kekerasan dan mengubah ciri-ciri bitumen. Oleh itu, kajian ini telah menyiasat kesan penambahan ejen pemulihan terhadap ciri-ciri fizikal dan kimia bitumen tua. Hubungkait antara ciri-ciri fizikal dan kimia bitumen juga dinilai dalam kajian ini. Ujian ciri-ciri fizikal yang telah dijalankan adalah Ujian Penusukan, Ujian Titik Lembut (SP), Kelikatan dan *Bending Beam Rheometer* (BBR). Ujian ciri-ciri kimia adalah *Fourier Transform Infra-Red* (FTIR) dan *Gas Chromatography-Mass Spectroscopy* (GC-MS). Ejen pemulihan berasaskan minyak bernama *cecabase* telah ditambah dengan beberapa peratusan yang berbeza iaitu 0.3%, 0.5%, 0.7%, dan 1.0% dari pada berat bitumen. Keputusan menunjukkan bahawa nilai penusukan meningkat dan kelikatan menurun dengan penambahan *cecabase*. Ujian SP dan BBR menunjukkan corak yang tidak konsisten. Melalui ujian FTIR, nisbah indeks sulfoksida, karbonil, dan aromatic menurun sementara indeks alifatik meningkat dengan penambahan ejen pemulihan. Keputusan ini membuktikan bahawa bitumen tua mengalami proses pemulihan. Keputusan ujian GC-MS menunjukkan bahawa komponen kimia bagi 0.7% kandungan ejen pemulihan menyamai bitumen kawalan. Hubungkait antara kedua ciri-ciri menunjukkan bahawa perubahan dalam ciri-ciri fizikal bitumen yang disebabkan oleh penambahan ejen pemulihan tidak semestinya memberi perubahan pada ciri-ciri kimia bitumen tersebut.

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## LIST OF ABBREVIATIONS

BBR	-	Bending Beam Rheometer
FTIR	-	Fourier Transform Infra Red
GS-MS	-	Gas Chromatography-mass spectroscopy
PEN	-	Penetration
RAP	-	Reclaimed Asphalt Pavement
SP	-	Softening Point
UTM	-	Universiti Teknologi Malaysia

## LIST OF SYMBOLS

MPA	-	Megapascal
RPM	-	Revolutions Per Minute
C	-	Celcius
PEN	-	Penetration

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# **CHAPTER I**

## **INTRODUCTION**

### **1.1 Overview**

In Malaysia, the construction and maintenance of current roads are continuing and developing. There was 61,000 km the total roads in Malaysia, with 17,500 km of major road currently in operation.(Zakaria and Sufian, 2009).

Malaysia is one of the countries that continue to grow with the volume of traffic increases every year. This situation still unbalanced with some of the facilities provided with transportation. The Manpower Minister Datuk Seri Fadillah Yusof said that the cost of repairing road damage due to flooding for the peninsular Malaysia estimated at RM660 million. Around 215 slopes needed costs road and bridge facilities. Repair costs estimated at RM1.09 billion, which RM9.5 million allocated for urgent action like building alternative roads on roads cut off the slopes and landslides. (BHonline, 2015)

### **1.2 Research Background**

Along with the development of the modern era, innovative technology from modern highways and convenient transportation also continue growing. The capacity and capability of flexible pavement have to increase with the increase in traffic flow. There are several factors considered to raise the performance of the flexible pavement. To reduce the costs and materials used in the road construction, many research have been conducted on reclaimed asphalt pavement (RAP). Using RAP

means reusing material from the milling and the destruction of old pavement. Some problems solved using this material such as reducing the use of virgin aggregates, eliminating landfill problems, saving non-renewable resources and reducing energy fuel consumption for processing and transporting materials. (Ongel and Hugener, 2015).

During the service life, the asphalt experience hardening and oxidation. Therefore, the aged bitumen becomes more rigid than fresh bitumen. It reduces the performance of hot mix asphalt (HMA). The rejuvenator or rejuvenating agent needed to restore the aged bitumen (Zargar *et al.*, 2012). The rejuvenator contains maltenes constituents to increase balanced the composition of the binders lost during the service life. Rejuvenator also softens the aged bitumen and increase the resistance of mixed cracks (Dinh *et al.*, 2018).

The addition of rejuvenator content forms a relationship between the chemical additions with the performance of the bitumen. Therefore, this study investigated the effect of adding rejuvenator on physical and chemical properties of aged bitumen.

### **1.3 Problem Statement**

The addition of rejuvenator content to the recycled bitumen gave the reaction and relation between the amounts of the rejuvenator with the recycled bitumen performance. It is necessary to find out the change of physical ability of recycled bitumen due to the chemical addition, because the physical properties test result shows the bitumen performance to load and weather condition.

In this study, the physical properties test evaluated to know the influence of rejuvenator content on the recycled bitumen. The chemical testing also implemented to find out the chemical composition change. Therefore, the testing result value for physical and chemical properties test reflected the amount of the rejuvenator content that gave the nearest result to the control bitumen. It is significant to evaluate the

relationship between the physical and chemical properties incorporating rejuvenator, so the addition of rejuvenator consider.

#### **1.4 Objectives of the Study**

This study was designed achieve the following objectives:

- (a) Evaluate the physical properties of recycled bitumen incorporating rejuvenator
- (b) Evaluate the chemical properties of recycled bitumen incorporating rejuvenator,
- (c) Determine the relationship between physical and chemical properties of the recycled bitumen incorporating rejuvenator.

#### **1.5 Scope of the Study**

The scope of work in this study started with extracting the RAP material to remove the bitumen content from the aggregate. The distillation carried out to get the aged bitumen. Furthermore, 40% aged bitumen of total weight mixed into 60% fresh bitumen and added the rejuvenator. Afterward, test the samples on the physical properties test (penetration, softening point, viscosity, and BBR) and chemical properties test (FTIR and GCMS).

## **1.6 Project Report Structure**

### Chapter 1: Introduction

Chapter 1 briefly describes the overall perspectives of the research including, overview, research background, problem statement, objectives, and scope of study that need to be achieved.

### Chapter 2: Literature Review

Chapter 2 gives several reviews from previous study and experiences related to laboratory recycled asphalt pavement incorporating rejuvenator.

### Chapter 3: Research Methodology

Chapter 3 explains the methods and procedures used in this study that divided into three stages.

### Chapter 4: Result and Discussion

Chapter 4 presents and discuss the findings from the results.

### Chapter 5: Conclusion and Recommendation

Chapter 5 describe the conclusions and several recommendations for future research.

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