FACTORS INFLUENCING THE STRENGTH OF FOAMED BITUMEN STABILISED MIX

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To my beloved Wife, Habibah Bt Ahmad, Son Muhammad Hyqal and
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ABSTRACT

Recycling of asphalt pavements has increased significantly since 1970 and in Malaysia the use of foamed bitumen as stabilizing agent was first introduced in year 2001. Recycling of asphalt pavements involves mixing of existing pavement material with stabilizing agent such as foamed bitumen, bitumen emulsion, cement or lime and placed on the milled pavement and compacted. Although the asphalt pavements recycling with foamed bitumen as stabilizing agent is gaining recognition and acceptance as a cost effective method of rehabilitating distressed pavement, so far in Malaysia no study has been carried out on the characteristic of foamed bitumen stabilized mix. The strength of foamed bitumen stabilized mix is influenced by factors such as cement content, moisture level and curing time. This study evaluates the effect of ordinary Portland cement as active filler, curing time and moisture content on the strength properties of foamed bitumen stabilized mix. Foamed bitumen treated samples with different RAP proportions were tested for their strength properties at various active filler contents, curing time and moisture contents. It was found that the strength in terms of resilient modulus, Unconfined Compressive Strength (UCS) and Indirect Tensile Strength (ITS) values, increased with curing time and percentage of active filler. It was also found that the maximum strength in terms of resilient modulus, Unconfined Compressive Strength (UCS) and Indirect Tensile Strength (ITS) was not at Optimum Moisture Content (OMC) and the strength decreased as the RAP proportion increased.

ABSTRAK

Kitar semula pavemen telah berkembang dengan pesat sejak tahun 1970 dan di Malaysia penggunaan bitumen buih sebagai ejen penstabil telah pertama kali diperkenalkan pada tahun 2001. Kitar semula pavemen melibatkan proses mencampur ejen penstabil seperti bitumen buih, bitumen emulsi, simen atau 'lime' dengan lapisan pavemen sediada, di baur, diturap semula dan kemudiannya dipadatkan. Walaupun kitar semula pavemen meggunakan bitumen buih sebagai ejen penstabil telah mendapat pengiktirafan dan diterima sebagai kaedah yang kos efektif untuk membaiki kerosakan jalan, namun setakat ini tiada kajian yang telah dijalankan mengenai ciri ciri campuran ini di Malaysia. Kekuatan atau prestasi campuran bitumen buih dipengaruhi oleh beberapa factor seperti kandungan simen, kandungan RAP, kandungan lembapan dan masa awet (curing). Kajian yang dijalankan ini menilai kesan kandungan RAP, kandungan simen, kandungan lembapan dan masa awet (curing) terhadap kekuatan campuran yang distabil dengan bitumen buih. Adalah didapati kekuatan campuran bitumen buih dari segi modulus, mampatan dan riceh bertambah dengan bertambahnya masa awet (curing) dan adanya kandungan simen. Didapati juga kekuatan maksima bagi modulus, mampatan dan riceh tidak berlaku pada kandungan lembapan yang optima. Kekuatan campuran juga menurun dengan bertambahnya kandungan RAP.

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LIST OF ABBREVIATIONS

ACWC	Asphaltic Concrete Wearing Course.
ACBC	Asphaltic Concrete Binder Course.
RAP	Reclaimed Asphalt Pavement.
C/R	Crusher Run.
OMC	Optimum Moisture Content.
MDD	Maximum Dry Density.
ITS	Indirect Tensile Strength test.
UCS	Unconfined Compressive Strength test.
TSR	Tensile Strength Ratio.
RM	Resilient Modulus test.
CR	Cold Recycling.
CIPR	Cold In Place Recycling.
HMA	Hot Mix Asphalt.
REAM	Road Engineering Association Malaysia.
PF	Percentage of Fine
BC	Binder Content.
OBC	Optimum Binder Content.
MMC	Moisture Mixing Compaction.
BSM	Bituminous Stabilised Mix.

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CHAPTER 1

INTRODUCTION

1.1 Background

Recycling of asphalt pavements has increased significantly since 1970. In Malaysia the cold recycling technique which involved in-plant recycling or in-situ recycling with foamed bitumen was first introduced in 2001. Since then the technique has become popular as a viable alternative pavement rehabilitation measure. The technique involves milling of existing pavement, mixed with the stabilizing agent and placed on the milled pavement and compacted. The most common stabilizing agents used for cold recycling in Malaysia are foamed bitumen, bitumen emulsion, cement and lime. The cold recycling process is carried out either in plant or in situ using purposed built recycling machine and recycled layer will form a new road base stabilized layer. It is a normal practice in Malaysia to overlay the newly stabilized roadbase layer with 60mm thick of binder course and 50mm thick of wearing course layers.

Although the cold recycling technique with foamed bitumen is gaining recognition as a cost effective method of rehabilitating distressed pavement, so far in Malaysia no study has been carried out on the characteristic of foamed bitumen stabilized mix. The performance of the recycled asphalt layer depends on the proportion of reclaimed asphalt pavement (RAP), types of stabilizing agents, and amount of cement [1]. Therefore, the purpose of this study is to evaluate in the laboratory the effects of RAP, moisture content, curing time and cement to the strength properties of foamed bitumen stabilized mix.

1.2 Problem Statement

A number of cold recycling projects with foamed bitumen stabilised mix have been completed in Malaysia for the past 10 years and on-going performance monitoring are in progress. However, despite such progress, option on foamed bitumen has been limited because of the lack of a standardized mix design, construction procedure and gaps that exist between the current knowledge and the knowledge that is needed to increase the probability of success when using this technology, particularly in the Malaysian hot and wet environment.

Important factors for the success of cold recycling works include site investigation, evaluation of existing materials, laboratory mix design and construction by appropriately skilled contractors. Before the cold recycling project start, representative samples from the existing pavement are obtained and samples are prepared to simulate as close as possible the property of material to be achieved during the actual recycling process, but it must be also noted that the mix design process or procedure cannot fully simulate what will happen in the field at the time of construction. Because of inconsistency of pavement layer thickness and moisture content from the existing pavement, field adjustments are sometime necessary, such as increasing water or stabilizing agent content.

This experimental laboratory works simulate the on- site condition of the foamed bitumen stabilised mix and the study is therefore aimed to answer problems with regard to the effect of RAP, cement content, curing time and moisture content to the strength properties of foamed bitumen stabilised mix. Among the problems faced during the construction of a cold recycling project are;

i. Proportion of RAP and the existing unbound material is not consistent, as the pavement layer thicknesses vary from place to place.

ii. During construction, it is difficult to meet the optimum moisture content (OMC) and maximum dry density (MDD) target, existing moisture content at the site normally varies from place to place.
iii. Before the recycling commences, cement in powder form is spread manually based on pre-determined percentage required. During construction the quantity or percentage of cement will vary because of the cement being blown away by the movement of heavy traffic and by strong wind.
iv. After the completion of recycling works, the determination of the appropriate curing time before foamed bitumen stabilised layer can be opened to traffic or be paved with asphaltic layer ACBC and ACWC depends on the judgment of the contractor based on previous experience.

1.3 Objectives

The objectives of this study are:

i. To investigate the effect of cement, moisture content and curing time at varying RAP proportions to the strength of foamed bitumen stabilised mix.
ii. To analyse and compare the results obtained with the requirement of the National Specification for Roadworks.
iii. To provide recommendations on the required cement content, moisture content and curing time for foamed bitumen stabilised mix based on the findings of the research.

1.4 Scope of the Study

The scope of the study covers the strength test for the foamed bitumen stabilised mix and the study is limited to the evaluation of the specimens prepared in the laboratory. The scope of this study is as follows:

i. To review and research the literature relating factors influencing the strength of foamed bitumen stabilised mix.

ii. Development of work flow chart and experimental test matrix for the study.

iii. Preparation of test specimens in accordance with prescribed procedures. For the purpose of this study the materials used are limited to;

- RAP from Grand Saga mill and replace project.
- Aggregate (CR) from Kajang Rock Quarry.
- Bitumen Penetration Grade 80/100 from SHELL.

iv. Investigation and laboratory testing on the strength of the foamed bitumen stabilised mix and the laboratory tests carried out are as follows:

- Unconfined Compressive Strength test (UCS).
- Indirect Tensile Strength test (ITS) at dry and soaked condition.
- Determination of Tensile Strength Ratio (TSR).
- Resilient Modulus Test (RM).

v. Analysis of the test results and evaluating the strength properties of the foamed bitumen stabilised mix.

vi. Findings, conclusion and recommendation from this study for further research.

1.5 Significance of the Study

Although the cold recycling technique with foamed bitumen is gaining recognition and acceptance as a cost effective method of rehabilitating distressed pavement, so far in Malaysia no study has been carried out to study the characteristic of foamed bitumen stabilized mix. Very little local data is available and the results and output of this study can be used for the development of standard specification and guidelines for cold recycling with foamed bitumen in Malaysia.

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