REVERSIBLE MOISTURE DAMAGE IN ASPHALT MIXTURE

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A project report submitted in partial fulfilment of the
requirements for the award of the degree of
Master of Engineering (Transportation)

School of Civil Engineering
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JANUARY 2019

DEDICATION

Specially dedicated to my supervisor, my family, and friends who encouraged me throughout my journey of education.

ACKNOWLEDGEMENT

First and foremost, all gratitude to the omnipresent Allah for giving me the strength through my prayers.

I would like to express my gratitude to my supervisor Dr. Haryati Yaacob for her cooperation, guidance, inspiration, and valuable bits of advice while doing this project.

In addition, I sincerely thank all the lecturers who have taught me, for the lessons delivered and the morals supported, not to forget mentioning my friends whom I sincerely thank for their useful ideas, suggestion, and help. I would like to express my love, gratitude, and appreciation to my beloved parents, my brothers, and my friends for their love, prayers, patience, support, and encouragement they provide during my studies.

ABSTRACT

A moisture damage has been one of the major concerns for HMA pavement by loss of adhesion between asphalt binder and aggregate surface or loss of the cohesion within asphalt binder due to action of water. Water is the one of major contributor towards the damage of asphalt pavement. The aim of this research is to evaluate the effects of moisture damage toward the performance of asphalt mixture under different conditions (dry, wet and dry back). The specimens were conditioned in accordance to ASTM D4867 to achieve desire saturation level up to 80% and then immersed in water for different soaking period to simulate flooding scenario. Indirect Tensile strength and Resilient modulus tests were performed on moisture conditioned specimens at regular interval (1, 3 and 5 days). After 5 days testing specimens were stored at room temperature for another 5 days to dry and were tested again to determine the recoverability of moisture damage. The results from this study indicated that tensile strength and modulus gradually decreased with the increasing of conditioning period, and upon drying at certain period specimens recovered 82% and 76% of initial ITS and Resilient modulus respectively. The results suggested that moisture damage in asphalt mixture tested is reversible.

ABSTRAK

Kelembapan adalah kerosakan yang menjadi salah satu kebimbangan utama bagi turapan HMA yang mengakibatkan kehilangan lekatan antara pengikat asfalt dan permukaan agregat atau kehilangan ikatan dalam pengikat asfalt akibat tindakan air. Air adalah salah satu penyumbang utama terhadap kerosakan turapan asfalt. Tujuan penyelidikan ini adalah untuk menilai kesan kerosakan kelembapan terhadap prestasi campuran asfalt dalam keadaan yang berbeza (kering, basah, separa basah). Spesimen dikondensasikan mengikut ASTM D4867 untuk mencapai tahap tepu sehingga 80% dan kemudian direndamkan ke dalam air untuk tempoh yang berbeza bagi mensimulasikan senario banjir. Indirect tensile strength dan Resilient modulus tests dilakukan pada spesimen yang lembap dengan selang masa (1, 3, dan 5 hari). Selepas 5 hari ujian, spesimen disimpan pada suhu bilik selama 5 hari untuk dikeringkan dan diuji lagi bagi menentukan kebolehan kelembapan dalam penghasilan kerosakan asfalt. Hasil daripada kajian ini menunjukkan bahawa kekuatan tegangan dan modulus secara beransur-ansur menurun dengan peningkatan tempoh masa, dan apabila spesimen mengalami pengeringan dalam tempoh tertentu, ianya pulih 82% dan 76% adalah keputusan awal daripada ITS dan Resilient modulus tests. Kajian ini mencadangkan bahawa kerosakan atas sebab kelembapan dalam campuran asfalt yang diuji dapat menghasilkan keputusan yang boleh ubah.

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LIST OF ABBREVIATIONS

MD	–	Moisture Damage
AM	–	Asphalt Mixture
ASTM	–	American Standard of Testing Materials
AASHTO	–	American Association of Highway and Transportation Official
ITS	–	Indirect Tensile Strength
RM	–	Resilient Modulus
TSR	–	Tensile Strength Ratio
FHWA	–	Federal Highway Works Administration
HMA	–	Hot Mix Asphalt
JKR	–	Jabatan Kerja Raya
TMD	–	Theoretical Maximum Density
OBC	–	Optimum Binder Content
UTM	–	Universal Testing Machine
VMA	–	Voids in Mineral Aggregates
VTM	–	Voids in Total Mix
VFB	–	Voids Filled With Bitumen

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CHAPTER 1

INTRODUCTION

1.1 General Background

Roads is one of the most essential modes of transportation system in the world and it plays vital role in economic and social development of a country. Many roads and highways have been constructed to cater the demands of the people or accomplish the requirements of the community for mobility by providing high quality transport networks which require to be maintained sufficiently. Most of the pavements across the globe are being and has been constructed since a long time using a product called asphalt. Asphalt mixture is being used in the whole world for construction of roads, highways and transportation infrastructure as it is cheaper than concrete. Similar to other artificial construction, it is deteriorated with the passage of time by the natural forces like rain, snow etc (Ahmad, N. 2011).

Bitumen and aggregates are the main constituents of an asphalt mixture. Moisture damage (MD) is induced by the loss of adhesion which commonly referred to as "stripping" of the asphalt film from the aggregate surface or a loss of cohesion within the asphalt binder itself, resulting in reduction in asphalt mix stiffness (Ahmad, N. 2011) (Terrel, R. L, Al-Swailmi, 1994). Moisture damage has found to be one of greatest causes of distress in asphalt pavements (Chen, X., & Huang, B. 008) (Leatherman, K. 2012). To overcome the effect of moisture damage, a huge amount of money have been spent by Malaysian local authorities in order to maintain the pavements and prolongation of their life. Although moisture is not responsible for impairment of the pavements directly, but to an extent, it enhances the speed and intensity of existing distresses e.g. cracking, raveling, rutting, potholes etc.(Miller, J.S. and Bellinger, W.Y., 2003). It also has been reported that moisture is responsible for deterioration of mechanical properties of asphalt mixture i.e. failure of stiffness and mechanical strength which finally could be a cause of breakdown of the road structure (Kakar, M. R., Hamzah, M. O., & Valentin, J. 2015). It is claimed by various researchers that moisture damage is a root cause of overuse failure of pavement and thus results in enhancement in rehabilitation works and conservation costs (Ahmad, N. 2011).

It is imperative to recognize materials and blends that are prone to damage driven by moisture. To determine the effect of moisture damage in mixture, there are many tests have been introduced but they don't indicate great connection between the outcomes got in the lab and the field execution of the mixtures (Solaimanian et al. 2003). In the majority of these tests the moisture damage is simply identified with the mechanical properties of the AM. The major drawback of these tests is that these tests haven't consider physical and chemical properties of bitumen and aggregate. These properties are most important to addressed because failure of bond between aggregate and bitumen is highly connected with individual properties of mixture constituents (MS-24, 2007). Bonding properties of materials is totally depend on surface characteristics of materials (Bhasin, 2006). Surface characteristics of materials represent by surface energy concept and used as a tool for selection of moisture prone materials (chang,2002)

1.2 Problem Statement

In many countries, the asphalt pavement is constantly exposed to wet conditions and high volume of water runoff due to heavy rainfall throughout the year. The prolonged exposure to water and moisture may expose the pavement to deterioration. According to Lu and Harvey (2007), air voids, pavement structure, rainfall intensity and pavement age have the highest influence on moisture damage while repeated loading and cumulative truck traffic have a marginal effect (Lu, Q., and Harvey, J.T. 2007).

A pavement shows an unexpected change in road condition after a disaster such as flooding. Currently in Malaysia, flood becomes one of the problem that leads pavements to early maintenance and rehabilitation. In 2014, the worst flood was occurred in Kelantan due to heavy rain. As a result, higher pavement deterioration was observed. According TH Tam et. al (2014), flood has cause huge economic losses in which the average annual flood damage in Malaysia is as high as RM 100 million (US $33million) (Tam, T.H., Ibrahim A. L., & Mazura , Z. 2014). Several studies have recognized that moisture interruption decreased the modulus of resilience (Mr) of granular and sub-grade layers. (Drumm, E. C., and Trolinger, W. D. 1997). Other studies, Monismith and Huang found an increase in pavement deflection due to a lower Mr, as a result reduction in pavement service life (Monismith, C. L. . (1992).

Therefore, asphalt pavement that was still fresh and new in terms of materials (aggregate and bitumen) and was badly damaged due to flood but still intact as a structure, will create concern on whether can it performed as it used to be. To what extend the flood has changed asphalt mixture properties and its internal structure. With poor foundations, the tensile stress on asphalt layer will becomes higher and it will reflect the capability of the asphalt layer to cater the load from the traffic. The strength and capability of future performance of flooded asphalt pavement will become an issue and need to be justify. Therefore, this study has looked into the performance of asphalt pavement that has been simulate as a flooded condition.

1.3 Objectives

The main aim of this study is to evaluate the effects of reversible moisture damage towards asphalt mixture performance. In order to achieve the aim of the study, the following objectives have been put forward:

1. To evaluate the effects of different moisture conditioning period towards the asphalt mixture performance
2. To evaluate reversable moisture damage in asphalt mixture at certain drying period.

1.4 Scope of Study

This study only involves AC14 as the dense graded asphaltic mixture. Specimens were submerged in water to simulate the flooding condition and also dried for same period to evaluate effects of reversible moisture damage in asphalt mixture. Performance test were then conducted to assess the performance of specimens.

1.5 Significances and Contributions of This Study

From the results of the study, the performance of asphalt mixture in terms of tensile strength and resilient modulus with different moisture conditioning period and the rate of recoverability of moisture damage can be obtained. Then, the effect of moisture on asphalt samples was determined by comparing the performance result for the condition and unconditioned sample can be consider for future research. Hence, the moisture damage for each sample for condition and unconditioned were evaluated. This performance result obtained should be taken into consideration for further studies in the future. Besides, it really hopes that this outcome of this study can contribute to minimize the moisture damage on the road structure due to flood. Moreover, roads in Malaysia were tendency to expose to moisture damage due to wet climatic condition. This performance result as one of the early initiatives for the researchers to produce the new solution to solve this moisture problem on road and ensure that road always on the good condition for the road user with the increased the pavement life.

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