INDIRECT TENSION TEST OF HOT MIX ASPHALT AS RELATED TO TEMPERATURE CHANGES AND BINDER TYPES

AKRIMA BINTI ABU BAKAR

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“Special dedication to my beloved parents Abu Bakar Bin Mahmud (rest in peace) and Sepiah binti Ali,

My brothers, Ahmad Fahmi, Ahmad Supian and Shamsul,

My sisters, Norhaslina, Noor Arifa and Raja Nor Qeeblat,

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ABSTRACT

Hot Mix Asphalt (HMA) can deteriorate and crack due to the repeated loading from traffic and change in temperature. This study is to evaluate the effects of temperature and binder types to the strength of asphalt layer. Four types of hot mix asphalt were considered in this study which were AC 10, AC 14, PMA 10 and PMA 14 and have been evaluated in the laboratory. For each type, the strength of the mixes have been compared related to different temperatures which are 25ºC and 40ºC using the Indirect Tension Test machine for resilient modulus according to ASTM D 4123 and the effect of binder types was also observed between bitumen type pen 80/100 and performance grade (PG) 76. Optimum bitumen content from Marshall Test results show that for AC10, AC14, PMA10 and PMA14 are 6.3%, 5.2%, 7.2% and 6.0% respectively. From the Indirect Tensile Modulus Test results it clearly shows that the values of resilient modulus decrease when the temperature is increase. AC10 and AC14 with bitumen 80/100 had higher resilient modulus at 25ºC compared to PMA10 and PMA14. However, at 40ºC the PMA10 and PMA14 shows vise versa. Bitumen pen 80/100 is suitable for low temperature condition because it has high resilient modulus value compared to PG76 but for high temperature, it is otherwise. From this study, PMA14 is found to be the best mix having the highest resilient modulus of all at 40ºC temperature, thus it is suggested that for Malaysia climate condition where the highest surface temperature is between 40ºC to 50ºC, PMA14 design is more suitable and will increase the pavement strength and lengthen the service time.

ABSTRAK

Sebahagian daripada punca kerosakan dan keretakan pada asphalt campuran panas (HMA) adalah disebabkan oleh beban trafik yang berulang dan juga perubahan suhu. Kajian ini adalah untuk mentaksirkan kesan yang disebabkan oleh suhu dan juga jenis pengikat kepada kekuatan lapisan asphalt. Empat jenis campuran digunakan di dalam kajian ini iaitu konkrit berasphalt dengan saiz nominal 10 dan 14 (AC10), (AC14), dan juga polimer asphalt diubahsuai dengan saiz nominal yang sama (PMA10) dan (PMA 14) dan kajian ini telah dilakukan didalam makmal. Kekuatan bagi setiap jenis campuran telah dibuat perbandingan berdasarkan dua jenis suhu iaitu 25ºC dan 40ºC menggunakan mesin Indirect Tension Test berdasarkan ASTM D4123. Kesan disebabkan pengunaan jenis pengikat yang berlainan juga diperhatikan antara pengikat jenis pen 80/100 dan juga jenis performance grade (PG)76. Daripada keputusan ujian Marshall, nilai kandungan bitumen optimum bagi campuran AC10, AC14, PMA10 and PMA14 adalah 6.3%, 5.2%, 7.2% dan 6.0%. keputusan ujian daripada Indirect Tension Test jelas menunjukkan bahawa nilai resilient modulus akan berkurang apabila suhu meningkat. Campuran AC10 dan AC14 dengan mengunakan pengikat pen 80/100 menunjukkan nilai resilient modulus yang tinggi pada suhu 25ºC berbanding dengan campuran PMA10 dan PMA14. Walaubagaimanapun, apabila suhu mencecah 40 ºC keputusan ujian menunjukkan sebaliknya. Bitumen pen 80/100 juga didapati lebih sesuai untuk suhu yang rendah berbanding bitumen PG76 yang mempunyai nilai resilient modulus yang lebih tinggi apabila suhu mencecah 40 ºC. Hasil kajian secara keseluruhannya menunjukkan bahawa jenis campuran PMA14 adalah jenis yang paling sesuai digunakan di Malaysia.

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LIST OF ABBREVIATIONS/SYMBOLS

ACW	-	Asphaltic Concrete for Wearing
PMA	-	Polymer Modified Asphalt
PG	-	Performance Grade
JKR	-	Jabatan Kerja Raya
TMD	-	Theoretical Maximum Density
AASHTO	-	American Association of State Highway and Transportation Officials
HMA	-	Hot Mix Asphalt
ASTM	-	American Society for Testing and Materials
OBC	-	Optimum Bitumen Content
VFB	-	Voids Filled With Bitumen
VTM	-	Voids in Total Mix
VMA	-	Voids in Mineral Aggregate

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CHAPTER 1

INTRODUCTION

1.1 Background

Parallel to the service time, flexible pavement can deteriorate and crack due to the repeated loading from traffic. A significant amount of effort has been made to predict the effects and causes of repeated traffic loads and environmental conditions to the pavement to find the best pavement design that overcome pavement damaged and lengthen the service time.

Flexible pavement is a structure composed of several layers of material placed on a subgrade, each of which receives the loads from above layer, spreads and distribute them out, then pass them to the layer below. Thus, the further down in the pavement structure a particular layer is the fewer loads it must carry. It was classified into three types which are hot mix asphalt (HMA), stone mastic asphalt (SMA), and porous asphalt. Each of them has their own advantages and disadvantages and different ability.

The phenomenon of cracking due to repeated traffic loads and the cumulative damaged in the flexible pavement, are influenced by many factors that includes the loading patterns, relief or rest period between successive loads, climatic and environmental factors and mix characteristic (P.S Baburamani,1992). The asphalt temperature and mix strength can leads to the pavement cracking. This parameter need to be considered as a factor in the design procedure.

In recent years flexible pavement structural evaluation has relied increasingly on determining material properties by laboratory testing. The indirect tension test has been identified as an economic and practical means of measuring the resilient modulus and the strength of pavement samples.

1.2 Problem Statement

Temperature and pavement strength are the important factors which influence the performance of road pavement. Attempts need to be made to evaluate the effect of these factors to the performance and design of the pavement. Climate is one of the importance factors which influence the road performance. Suitability mix needs to be determine to make sure that the mix design will withstand the environmental climate and increase it service lifetime also avoid early cracking or rutting to the pavement. Repeated loading from the traffic will decreased the pavement strength and reduce it performance. Thus, study need to be done to overcome these problems and find the most suitable design that has high strength and more durable.

1.3 Objectives of the Study

The aim of this study is to investigate the indirect tension of various hot mix asphalt mixtures. In this study the resilient modulus of the pavement was determined with different temperature. The objective of this study is to evaluate the effects of temperature changes and binder types on the resilient modulus of various of hot mix asphalt (HMA).

1.4 Scope of the Study

The scope of study involved four different of mixes namely Asphaltic Concrete 10, Asphaltic Concrete 14, Polymer Modified Asphalt 10 and Polymer Modified Asphalt 14. After that 3 verification samples from each type was tested using the Indirect Tension Test to get the resilient modulus with different temperature. The differences of each samples was compared based on the results. The tests will be performed according to ASTM and JKR standard procedure. The tests include Marshall and Indirect Tensile Test and will be conducted at Transportation Laboratory.

1.5 Significant of the Study

From the result of this study, the performance of pavement to withstand temperature changes and the strength of each pavement types can be obtained. Then, the samples will be compared to each other based on the results and after that conclusion and recommendation will be made based on the comparison. The most suitable design with temperature and high strength maybe can be consider in the future design of pavement. With the outcome result, hopefully that new design that can prolong the cycle time of cycle and prevent crack can be created. It is also can reduce the highway maintenance cost in the future.

5.2 Conclusion

Generally, climate changes and binder type are the important factor that affecting pavement design. From this study, following conclusions may be drawn;

(i) The result for optimum bitumen content show that, when comparing between gradation AC10/PMA10 to AC14/PMA14, bitumen content for gradation AC10/PMA10 need more bitumen even though the mixes used different type of binder.

(ii) The strength of the resilient modulus will increase with the decreasing of temperature. However the value did not meet the specification of SPJ/JKR/2008.

(iii) From the Indirect Tensile Modulus Test, it shows that the value of resilient modulus will decrease when the temperature is increased.

(iv) Bitumen pen 80/100 is suitable for low temperature condition because it has high resilient modulus value compared to PG76.

(v) For Malaysia condition it is suggested that PMA14 design be the best design for road construction because it is suitable with Malaysia climate condition and give high strength for the pavement.

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