EVALUATION OF THE COMPACTIVE EFFORT ON THE STRIPPING CHARACTERISTIC OF HOT MIX ASPHALT (HMA) MIXTURES

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This project report is dedicated to my beloved parents,
my wife Shanda A/P Periannan as well as
my two kids Ugashni Naikker and Reshee Alvin Naikkerr

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ABSTRACT

Generally, moisture susceptibility is a HMA mixture's tendency towards stripping. To combat moisture susceptibility, proper mix design is essential. However if a mix is properly designed but not compacted sufficiently it could be also subjected to stripping. This study is to evaluate the relationship between different compactive efforts on stripping, as well as to suggest the most appropriate indicative test to envisage the stripping characteristic in HMA mixtures. Two test methods were carried out to assess the stripping, which are quantitative strength test for compacted specimens and qualitative test for loose uncompacted specimens. Samples compacted with 35, 50 and 75 blows of Marshall hammer were used to determine the stripping in HMA. For the quantitative test, moisture induce damage test (AASTHO T 283) is utilized to forecast the stripping while for qualitative test, Coating and Stripping of Bitumen-Aggregate Mixtures (ASTM D1664-80) and Effect of Water Bituminous-Coated Aggregate Using Boiling Water (ASTM 3625-91) were used. The results show that increase in compactive effort would decrease the optimum asphalt content. In the moisture induce damage test, those 35 blows and 50 blows have larger TSR value, which the 35 blows is 24% and 50 blows is 14% higher than 75 blows. Similarly, the loose uncompacted specimens indicate that both of these lower blows have lesser stripping potential. This shows that, the lower the blow the larger optimum asphalt content thus decreases the stripping potential of the HMA. Besides that, it was also found that moisture induce damage test is a more appropriate method to use in evaluating of stripping characteristic of HMA.

ABSTRAK

Amnya, tindakan air dalam sesuatu campuran berasfalt (HMA) akan mendorongkan kepada penanggalan agregat. Bagi mengelakkan fenomena ini, suatu campuran yang baik diperlukan. Walaubagaimanapun, sesuatu campuran yang direkabentuk dengan baik tetapi sekiranya tidak dipadatkan secukupnya akan menyebabkan penanggalan agregat. Kajian ini dijalankan untuk menilai hubungan diantara usaha pemadatan keatas penanggalan agregat serta mencadangkan suatu ujian indikatif yang sesuai untuk meramal penanggalan agregat dalam sesuatu campuran asphalt. Dalam penentuan penanggalan agregat dua kaedah ujian telah digunakan, iaitu ujian kuantitatif bagi spesimen yang telah dipadatkan dan ujian kualitatif untuk spesimen yang tidak dipadatkan. Sampel yang dipadatkan pada 35, 50 dan 75 hentaman dengan menggunakan tukul Marshall digunakan untuk mengetahui potensi penanggalan agregat. Bagi ujian kuantitatif prosedur "*Moisture induce damage test*" (AASTHO T 283) digunakan untuk meramalkan penanggalan agregat manakala bagi ujian kualitatif, ujian "*Coating and stripping of bitumen-aggregate mixtures*" (ASTM D1664-80) dan **"***Effect of water bituminous-coated aggregate using boiling water*" (ASTM 3625-91) telah digunakan. Keputusan menunjukkan bahawa peningkatan bilangan hentaman akan mengurangkan kandungan optimum asfalt. Dalam ujian "*moisture induce damage test*" hentaman 35 dan hentaman 50 mempunyai nilai " *Tensile Strength Ratio*" (TSR) agak tinggi, dengan hentaman 35 adalah 25% dan hentaman 50 adalah 14% lebih tinggi daripada hentaman 75. Begitu juga, dengan spesimen yang tidak dipadatkan, di mana ia menunjukkan bahawa kedua-dua hentaman yang rendah mempunyai potensi penanggalan yang kurang. Ini menggambarkan bahawa hentaman yang rendah akan memperolehi kandungan optimum asfalt yang tinggi dan akan mengurangkan potensi penanggalan agregat daripada sesuatu campuran HMA. Selain dari itu, dapat dikenalpasti bahawa ujian "*moisture induces damage*" adalah ujian yang sesuai untuk menentukan potensi penanggalan agregat dalam sesuatu campuran HMA.

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AC	-	Asphalt concrete
CA	-	Coarse aggregates
FA	-	Fine aggregates
S	-	Percentage of water absorption
SG	-	Specific gravity
St_1	-	Average tensile for unconditional subsets
St_2	-	Average tensile for conditional subset
TMD	-	Theoretical maximum density
TSR	-	Tensile strength ratio
V_a	-	Volume of air void
V_{sample}	-	Volume of samples
V_w	-	Volume of water
VTM	-	Void in total mix
W_{agg}	-	Weight of aggregates
W_{asp}	-	Weight of asphalt
W_{dry}	-	Weight of samples in air
W_{wet}	-	Weight of Samples in water
W_{SSD}	-	Weight of samples surface saturated dry
W_{sat}	-	Weight of saturated samples surface saturated dry

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CHAPTER 1

INTRODUCTION

1.1 Introduction

A flexible pavement constructed with asphaltic cement and aggregate and consists of several layers as shown in Figure 1.1. The lower layer is most vital layer in flexible pavement construction. A well compacted subgred will enhance the strength of the pavement. The principle reason of compaction is to increase the strength, lowers the compressibility and reduces the permeability of a soil by rearranging its fabrics. The soil fabrics are forced into a denser configuration by the mechanical used in compaction.

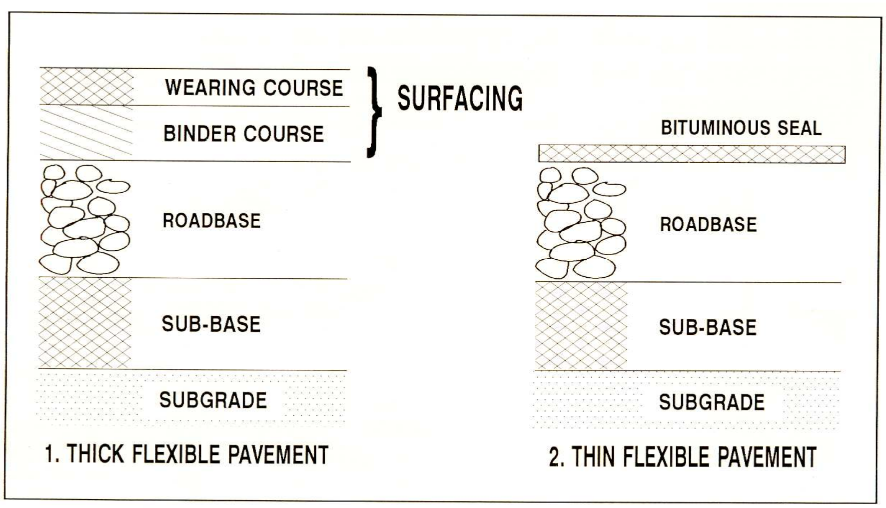

Figure 1.1: Cross section of a flexible road pavement (IKRAM, 1994)

The state of compaction of soil is conveniently measured using the dry density, the attainable values of which are related to the water content. In the event, the number of compactive effort is increases the optimum water content will decrease. This phenomenon happens due to the reduction of air volume in the soils. Like wise soil, the compactive effort theory can be implemented in the hot mix asphalt (HMA).

In HMA design compaction is the process of compressing a given volume of asphalt into smaller volume. It is accomplished by pressing together the asphalt coated aggregate particles, there by eliminating most of air void (space**)** in the mix and increasing the density (weight to volume ratio) of the pavement mixture. Figure 1.2 is a graphical presentation of the effect of air void on pavement durability. The higher the air void in the HMA the higher will be the stripping potential.

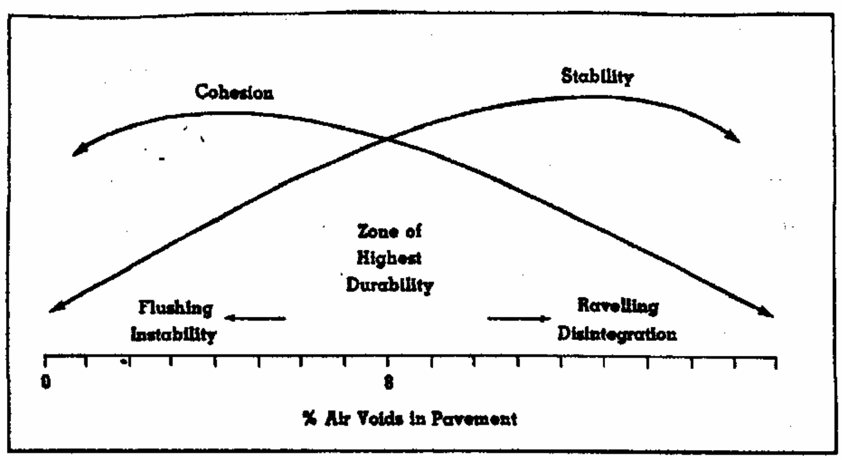

Figure 1.2: Pavement Durability vs. Air Void (Asphalt Institute Manual Series No.22, 1983)

The mix proportions for a properly compacted asphalt concrete are determined in laboratory during mix design testing. The ability of a properly proportioned asphalt concrete mixture is to resist potentially damaging effects of the asphalt binder stripping from the aggregate particles. To perform properly in the field, a well designed asphalt concrete mixture must be adequately compacted.

However there is, possibility for properly design mix to strip resulting from poor field compaction that produced high void contents allowing water to enter hot mix asphalt layer. Therefore, there is a need to assess each mixture to determine, the suscepblility of asphalt concrete mixture to water damage.

In this project, laboratory tests on the HMA design were carried out to scrutinize the stripping potential for the three different types of compactive effort. Based on the laboratory result, the effect of compaction effort on stripping potential of HMA are analyzed and recommended.

1.2 Background

Stripping is the common distress amongst other distress occurring in hot mix asphalt (HMA) pavements in the Malaysia. Pavement performance is adversely affected by stripping and unforeseen increases in maintenance budgets are often incurred. The causes of stripping remain doubtful and preventability is rather non-deterministic. For that reason need to make known the understanding of the stripping mechanisms, and developed simple but reliable test. Moisture damage of asphalt cement pavement is a problem that Malaysian road network are experiencing. This damage is commonly known as stripping. The dominant failure mode is the separation of the asphalt coating from the aggregate. An alternate mode that is gaining acceptance is the loss of cohesion of the asphalt cement (Parker and Gharaybeh, 1988).

The most serious consequence of stripping is the loss of strength and integrity of the pavement. Stripping can take on many surface forms during its progression. However, stripping in a particular area may be quite severe before any surface indicators are evident. Surface indicators may include rutting, shoving and/or cracking. Pavement performance is adversely affected by stripping and unforeseen increases in maintenance budgets are often incurred.

Numerous test methods have been developed and functional in the past to envisage the moisture propensity of asphalt mixes. The developed tests can be classified into two categories, qualitative tests and quantitative strength tests. The Boiling Water Test (ASTM D3625) and Static-Immersion Test (AASHTO T182) are qualitative tests, while the Lottman Test (NCHRP 246), Tunnicliff and Root Conditioning (NCHRP 274), Modified Lottman Test (AASHTO T283), and Immersion-Compression Test (AASHTO T165) are quantitative strength tests (Roberts et al, 1996).

1.3 Problem Statement

The Malaysia road network has expended rapidly in line with pace of economic growth. The main mode for movement of nation good (freight) with the country is through road networks and Jabatan Kerja Raya (JKR) being principal government department responsible for road work.

The road pavement in this country is constructed based on JKR's *Standard Specification for Road Works, JKR/SPJ/1988*. However these pavements are still susceptible to deterioration that could be due to vast increased in traffic volume in short period of time and/or improper mix design. The rate of deterioration will depend on the severity of the traffic loads, variability of road material and compaction as well.

In accordance with AASHTO Test Method T245, 75 blow/face compactive efforts are used to obtain higher density of an asphalt concrete mixture. Density is very vital in pavement construction. The principal reason to compact sufficiently is to reduce the air void and increase the mixtures stability, however it become difficult to obtain desired density when the asphalt cement content in the mixture is low which causes durability problem in the long term. Even so, Jabatan Kerja Raya (JKR) are using 75 blow/face compactive efforts in design mix and it is known that, the higher the compactive effort the lesser optimum bitumen content is required.

Less amount of asphalt during compaction effort in laboratory mix design could contribute to stripping. Thus, there is a need to investigate and determine the test that can better predict, stripping of HMA. Beside that, there is also a need to identify what compactive effort should be employed.

Increase in asphalt film thickness can significantly reduced the rate of aging and effect of high void. However if asphalt cement film is too thin, air which enters the compacted pavement can more rapidly oxidize the thin film, causing the pavement become brittle and to fail prematurely by cracking. Additionally if the aggregates are susceptible to water damage, thin film is more easily penetrated by water than thicker one.

The load carrying ability of an asphalt pavement is a function of both thickness of material and its stiffness. Lacking in this will resulted to pavement distress such as stripping. This phenomenon occurs due to decrease in pavement durability, which has been stressed to the limit of its fatigue life by repetitive axle load application.

1.4 Objective

The principal objectives of this study are as stated below:

i) To evaluate the effect of compaction efforts on stripping potential HMA.

ii) To evaluate the most appropriate indicator test for stripping potential.

1.5 Scope of the Study

This scope covers the process needed in carrying out an evaluation on testing procedures used to determine stripping potential in the Asphalt Wearing Coarse (ACW 14) mixtures. This involves wide-ranging of laboratory works comprising by laboratory mix design and performance test. During the mix design the compactive effort was varied to provide the variability in the results. The entire test were conducted at Highway and Transportation laboratory of University Teknologi Malaysia. Data available were analyzed and results are presented in the project report.

1.6 HMA Mixture Design

HMA is defined as a combination of heated and dried mineral aggregates that are uniformly mixed and coated with a hot asphalt binder (Lavin, 2003). The design of HMA and other mixtures mostly involve selecting and proportioning ingredients to obtain specific construction and pavement performance properties. The ultimate goal is to find an efficient blend and gradation of aggregates and asphalt binder that give a mixture that has:

i) Enough asphalt binder to ensure a durable compacted pavement and bonding the aggregate;

ii) Enough workability to permit mixture placement and compaction without aggregate isolation;

iii) Enough mixture stability to endure the repeated loading traffic without distortion or displacement;

iv) Sufficient void or air spaces in the compacted mixture to allow a slight additional amount of added compaction by the repeated loading of traffic. The air void will prevent asphalt bleeding or loss of mixture stability. The volume of air voids should not be so large to allow excessive oxidation or moisture damage of the mixture; and

v) The pertinent selection of aggregates to endow with skid resistance in high-speed traffic application.

1.7 Mixture Design Specification

The United Army Corps of Engineers uses Marshall mixture design specification for airfield construction which originally developed by Bruce Marshall a employee of Mississippi Highway Department (Goetz, 1989). The Asphalt Institute and highway group further modified these specifications to meet the road constructions requirement. The mixture specification considering pavement loading which grouped by traffic level or ESALs.

The goals of this laboratory compaction process is to stimulate as closely as possible, the actual compaction effort procedure in the field by roller and traffic. A standard 50 blows/face compactive effort was used in Marshall laboratory test. Further research used 75 blows/face compaction efforts to obtain higher stability to cater greater loadings from traffic. However, the drawback was that the amounts of optimum asphalt content become less which resulted in thinner asphalt film thickness. Some studies have shown that the thinner the asphalt film thickness the higher the stripping potential of the mix.

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