THE ENVIRONMENTAL EFFECT ON THE COOLING RATE OF HOT MIX ASPHALT PAVEMENT

WARDATI BINTI HASHIM

A project report submitted in partial fulfillment of the requirements for the award of the degree of Master of Engineering (Civil-Transport & Highway)

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ABSTRAK

Permintaan tinggi terhadap jalan berturap asfalt yang baru menyebabkan kerja-kerja penurapan terpaksa dilaksanakan dalam keadaan yang tidak bersesuaian seperti suhu persekitaran yang rendah, tahap kelajuan angin yang tinggi atau kerja-kerja turapan pada waktu malam yang akan mempengaruhi kadar penyejukan campuran panas asfalt seterusnya memberi kesan terhadap tempoh pemadatan. Kadar penyejukan yang tinggi akan mengurangkan tempoh pemadatan. Di Malaysia, kawalan tempoh masa pemadatan yang digunakan hanyalah berdasarkan had suhu antara penghantaran dan penghamparan sesuatu campuran panas asfalt tersebut. Tiada sebarang penentuan terhadap kawalan masa pemadatan, khususnya yang berkaitan dengan kesan keadaan setempat. Oleh yang sedemikian, kajian ini dilaksanakan dengan objektif untuk menilai kesan persekitaran terhadap kadar penyejukan campuran panas asfalt serta dengan sasaran untuk menentukan tempoh pemadatan yang bersesuaian. Kajian dijalankan dengan melaksanakan ujian-ujian makmal dimana ia melibatkan parameter ujian seperti cahaya matahari, suhu sekitar dan tapak (perbandingan kesan pembinaan sewaktu malam dan siang) serta variasi kelajuan angin. Ujian akan dilaksanakan dengan memfokuskan kepada campuran jenis ACW 14 bagi lapisan haus dan jenis ACB 28 bagi lapisan pengikat. Sampel dibancuh dalam acuan berbentuk empat segi dan dipadatkan menggunakan penggelek besi. Bacaan suhu diambil pada bahagian tengah dan permukaan sampel. Suhu bancuhan adalah berdasarkan spesifikasi JKR. Sampel kawalan disediakan bagi setiap jenis campuran untuk tujuan perbandingan dengan sample ujian dan ia diuji di makmal tanpa sebarang kesan angin dan cahaya matahari. Daripada keputusan yang didapati, dapat dirumuskan bahawa kadar penyejukan campuran asfalt panas adalah sangat dipengaruhi oleh kesan persekitaran seterusnya memberi kesan kepada tempoh pemadatan. Apabila dibandingkan dengan sampel kawalan, tempoh pemadatan sampel ujian menurun antara 15-50% ketika keadaan berangin dan malam manakala meningkat sehingga 100% ketika keadaan siang.

ABSTRACT

High demand for new asphalt pavements often requires that paving be done in an unfavorable condition such as low air temperatures, high speed winds, and night construction that will influence the cooling rate thus affecting the Time Available for Compaction (TAC). Higher cooling rate will reduce the TAC. In local practice, the asphalt paving compaction control mechanisms quoted from the locally used specifications are normally based on the limits of the delivery and laying completion temperatures. There are no items to predict these control elements and to be specifically related to the local conditions. This study was carried out with objective to investigate the environmental effect on cooling rate, aiming to determine the appropriate Time Available for Compaction (TAC) using laboratory tests which include the study parameter; solar flux, base and ambient temperature (daytime and night paving) and wind velocity focusing at HMA ACW 14 of mix type for wearing course and ACB 28 of mix type for binder course. Samples were prepared in slab mold, compacted using manually operated steel roller. Temperature measurements were taken from slabs at middle and surface position. Temperature of mixing was based on JKR specification. A controlled sample was prepared for each mix type, tested in the laboratory without any wind velocity and solar flux effect. Based on the result obtained, it can be concluded that the cooling rate of HMA is significantly affected by the environmental factor thus influencing the TAC. The TAC tend to decrease by 15-50% during windy and night condition while increase up to 100% during daytime condition.

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LIST OF ABBREVIATIONS/SYMBOLS

ACW 14	-	Asphaltic Concrete Wearing with Nominal Maximum Aggregate Size 14mm
ACB 28	-	Asphaltic Concrete Binder with Nominal Maximum Aggregate Size 28mm
ASTM	-	American Society for Testing and Materials
AASHTO	-	American Association of State Highway and Transportation Officials
G_{mb}	-	Bulk specififc gravity of compacted mix
G_{sb}	-	Combined bulk specific gravity of total aggregate
G_{mm}	-	Theoretical maximum density
HMA	-	Hot Mix Asphalt
NMAS	-	Nominal Maximum Aggregate Size
NAPA	-	National Asphalt Pavement Association
JKR	-	Jabatan Kerja Raya
OBC	-	Optimum Bitumen Content
SSD	-	Saturated Surface Dry
TAC	-	Time Available for Compaction
TMD	-	Theoretical Maximum Density
VTM	-	Voids in Total Mix
VMA	-	Voids in Mineral Aggregate
VFB	-	Voids Filled with Bitumen

CHAPTER 1

INTRODUCTION

1.1 Background

Hot Mix Asphalt (HMA) is one of the most often used material for road pavement. Usually being produced at the premix plant, HMA after spread onto the pavement surface, needed to be compacted to a specific range of density in order ensure that a stable and durable pavement is built (Brown, et.al. 2004).

HMA spread onto the road surface is most often freshly hot from the premix plant with the temperature around 140^0C to 160^oC (Roberts, et.al.1996) thus making the bitumen under liquid condition easily getting attached to those aggregates. Through the process of cooling in which the mix tends to lose heat, the previous temperature of HMA shall decrease within certain period of time until it becomes stable. This process will usually relate to the time available for compaction thus the compaction job should be done within the particular HMA cooling time to achieve desired density.

Rate of cooling is usually affected by various factors which include grading, lift thickness as well as environmental factor such as wind, sunlight thus making compaction process usually having inadequate time which results to less durable pavement.

1.2 Problem Statement

High demand for new asphalt pavements often requires that paving be done in unfavorable construction conditions. Low air temperatures, high winds, and night construction create adverse conditions for hot-mix asphalt paving. These conditions may occur at any time. This presents a risk for owners and contractors. According to Collins,et.al (2006), to achieve optimum load-bearing and weathering characteristics, an asphalt mix must be compacted to a specific range of density, and the time required for HMA to reach the proper compaction temperature to achieve this density decreases with an increased rate of cooling.

Hot-mix asphalt compaction is generally begun as soon as the mix can support the roller weight. The roller operator determines the best time to begin compaction by means such as judging the depth of a heel imprint. This method works well when the ambient temperature is high enough. However, low ambient temperatures, high wind speeds, and night construction increase the rate of heat loss from the mix (Newcomb, 1998). During these conditions, the ability to predict mix temperature is more critical because the Time Available Compaction (TAC) is decreased.

In local practice, the control mechanisms quoted from the locally used specifications are normally the acceptable limits of delivery and laying completion temperature. There are no items to predict these control elements and to be specifically related to the local conditions. Therefore, research is needed to validate these limits in order to be specifically related to the local conditions, i.e. material characteristics, environmental conditions and compaction mechanisms to suite locally environmental conditions.

Less research had been done on this topic as it includes lots of parameters to be tested. However, Jendia and Jerada (2005) research focusing on TAC and time opening traffic (TOT) and a research focusing on HMA thermal properties during construction (Chadbourn, et.al. 1996) can be referred to.

1.3 Objective

The objective of this research is to investigate the cooling rate of HMA affected by the environmental factor by conducting laboratory tests which will then indicate the TAC.

1.4 Aim

The research was carried out with the aim to determine the Time Available for the Compaction (TAC). This is supposed to lead to a better control during compaction process thus making a proposal of specifications to be used in the local industry related directly to the asphalt compaction procedures.

1.5 Scope of Research

The research focused on parameters tested to see the effect on the cooling rate of HMA. Those parameters included solar flux, base and ambient temperature (tested according to time of paving - daytime and night time) and wind velocity effect

Tests were conducted on two types of mix which were ACW 14 for wearing course of and ACB 28 for binder course. As the tests focused on the effect of environmental, the sample thickness was made constant which was 50mm for both types of mix.

1.6 Flow of Chapter

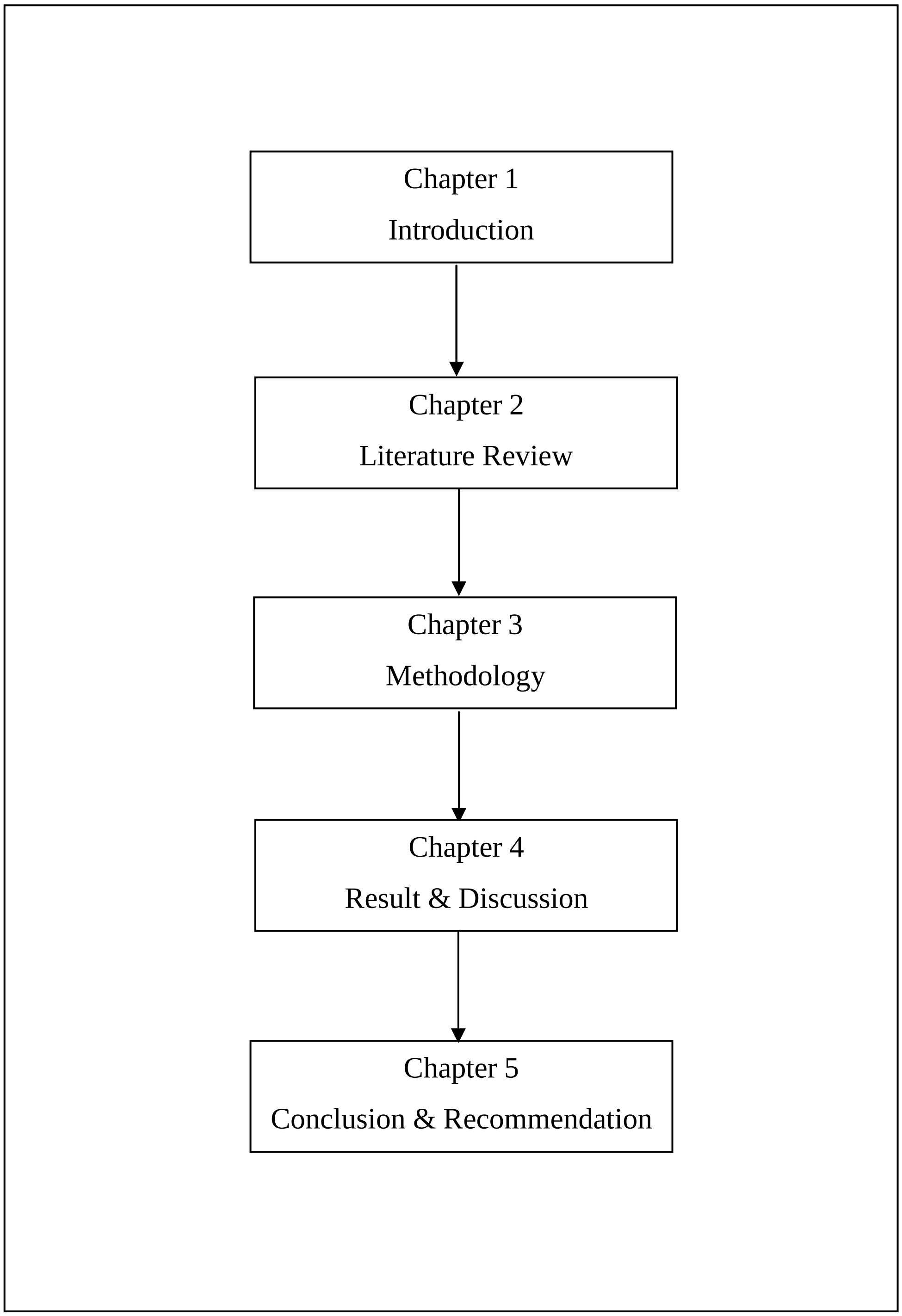

Figure 1.1: Flow of chapter in the research

Figure 1.1 shows the flow chapter involved in the research. Chapter 1 tells about the introduction to the research by discussing on some background related to the topic and explaining the problem statement which lead to the selection of research title, objective, aim and scope.

While in Chapter 2, literature review is done to give a preliminary view on the research being done as well as to create strategies for the research to be carried out. The literature review will refer to previous researches that were presented in a form of dissertation, working paper or journal. .

When it is done with the literature review, methodology is selected and explained in Chapter 3. Methodology functions as a necessity in acquiring data of research. As for this research, data are acquired from the laboratory test and the result will then be explained and discussed in Chapter 4. Result will base on analysis being carried out, referring to the theories which have been set up.

Finally, conclusion and recommendation is discussed in Chapter 5. In this chapter, explaination is done on whether the research complies to the objectives and theories. It may conclude on how the result of the research might affect the way paving process being carried out in the industry. Furthermore, recommendations are given out for any upcoming reserach related to the topic.

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