

**EVALUATION OF HOT MIX ASPHALT (HMA) PROPERTIES  
COMPACTED AT VARIOUS TEMPERATURES**

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A project report submitted in partial fulfillment of the requirement for the award of  
the degree of Master of Engineering (Civil – Highway and Transportation)

Faculty of Civil Engineering  
Universiti Teknologi Malaysia

NOVEMBER 2005

*My beloved family.....mother and father.....brother and sister  
May god bless be upon them, and last but not least, Irene Gabriel*

## ACKNOWLEDGEMENT

I would like to express my greatest appreciation to my master project supervisor, Dr Mohd Rosli Hainin for his guidance and motivation until the completion of this project. His kindness and caring gives me strength to complete this project. May god bless him with good health and joy in life. I am also indebted with Faculty of Civil Engineering, UTM for giving me place to gain more knowledge in higher education level.

Thanks to lab technicians, Mr Azman and his friends for their guidance and help when using the apparatus and useful technique to conduct test on prepared sample. Their help is much appreciated. In addition, special thanks to my entire postgraduate friend that assists me in term of data collection, and various help that makes this report more accurate and high quality.

To my father and mother, thank you very much for financial support and love they have share with me. I owe them very much and i am lucky to have them in my life.

## ABSTRACT

Hot mix asphalt (HMA) mixture compacted at various temperature has always been a concern to researcher. Compaction below the standard compaction temperature may bring reverse effect on HMA properties. Moisture damage of HMA with low temperature referred as striping and this problem become prevalent in recent years. This project is to determine the Marshall properties of compacted mix and moisture susceptibility of mix. In this study asphaltic concrete of wearing course with 14mm nominal maximum aggregate size (ACW14) and 20mm (ACW20) were used and test involved were Marshall Test and AASHTO T283 for moisture susceptibility. Samples were compacted at various temperature namely 85°C, 100°C, 115°C, 130°C, 145°C, and 160°C. Result shown that most samples have low density, low flow value and very stiff when compacted at lower temperature. Tensile strength ratio (TSR) for mixes compacted above 115°C is more than 80% and this shown that mix still stable at minimum temperature of 115°C for ACW14. ACW20 has TSR more than 80% when compacted at 130°C and above. This suggests that as mixes get coarser the minimum compaction should be higher. For Marshall Stability, the result indicates that as the compaction temperature increases, the stability increase. However for compaction temperature above 145°C, the stability slightly drops. This could indicates that 145°C is the optimum compaction temperature.

## ABSTRAK

Konkrit asfal campuran panas dipadatkan pada suhu yang sesuai untuk menghasilkan turapan jalan yang berkualiti. Pemadatan pada suhu dibawah spesifikasi akan memberi kesan negatif terhadap parameter campuran. Masalah ancaman kelembapan terhadap asfal campuran panas banyak dikaji oleh pakar jalan raya dan jurutera. Masalah kelembapan juga menyebabkan masalah lain akan timbul seperti penjujukan dan keretakan. Projek ini dijalankan untuk mengkaji parameter Marshall bagi asfal campuran panas yang dipadatkan pada suhu tertentu. Dua jenis bancuhan digunakan iaitu lapisan asfal haus dengan saiz nominal agregat 14mm (ACW14) dan 20mm (ACW20). Antara ujian makmal yang terlibat ialah seperti ujian Marshall dan ujian AASHTO T283. Sampel ACW14 dan ACW20 akan dipadatkan pada suhu 85°C, 100°C, 115°C, 130°C, 145°C, dan 160°C. Keputusan ujikaji menunjukkan bahawa campuran akan berketumpatan rendah, mempunyai nilai aliran rendah, dan agak keras apabila dipadatkan pada suhu yang rendah. Nilai nisbah tegasan (TSR) bagi sampel ACW14 adalah melebihi 80% apabila ia dipadatkan pada suhu 115°C, manakala sampel ACW20 memerlukan suhu setinggi 130°C untuk mencapai 80% nilai nisbah tegasan. Kajian ini juga menunjukkan bahawa semakin kasar agregat yang digunakan, semakin tinggi suhu pemadatan yang diperlukan. Nilai kestabilan Marshall akan meningkat seiring dengan peningkatan suhu pemadatan bancuhan. Terdapat penurunan nilai nisbah tegasan bagi kedua-dua sampel apabila suhu pemadatan melepasi 145°C. Ini menunjukkan bahawa 145 °C adalah suhu pemadatan optimum bagi kedua-dua sampel.

## LIST OF CONTENT

<b>CHAPTER</b>	<b>TITLE</b>	<b>PAGE</b>
	Declaration of the Status of Thesis	
	Supervisor Declaration	
	Title Page	i
	Declaration of originality and exclusiveness	ii
	Dedication	iii
	Acknowledgements	iv
	Abstract	v
	Abstrak	vi
	Table of Contents	vii
	List of Tables	xii
	List of Figures	xiv
	List of Graphs	xv
	List of Symbols	xvii
	List of Appendices	xviii
<b>CHAPTER 1</b>	<b>INTRODUCTION</b>	
	1.1 Background study	1
	1.2 Objective of the study	3
	1.3 Scope of the study	4

<b>CHAPTER 2 LITERATURE REVIEW</b>	<b>PAGE</b>
2.1 Introduction	5
2.2 HMA Composition	6
2.2.1 Asphalt cement	6
2.2.2 Aggregate	8
2.2.3 Sedimentary	8
2.2.4 Igneous	8
2.2.5 Metamorphic	9
2.3 Maximum particle size and gradation	9
2.3.1 Maximum particle size	9
2.4 Aggregate gradation	10
2.5 Specific gravity of aggregate	11
2.6 Air void ( $V_a$ ), VMA, and effective asphalt content ( $P_{be}$ )	11
2.7 Temperature effect	13
2.8 Moisture damage	15
2.9 Element in moisture damage	15
2.10 Test on moisture damage or susceptibility	18
2.10.1 Indirect tensile test	19
2.11 Mix design method	22
2.11.1 U.S Army Corps of Engineer or Marshall Method	23

<b>CHAPTER 3 RESEARCH METHODOLOGY</b>	<b>PAGE</b>
3.1 Introduction	25
3.2 Material preparation	27
3.3 (T166) Bulk Specific Gravity of Compacted Bituminous Mixtures using Saturated Surface Dry Specimen	28
3.3.1 Samples Preparation	30
3.3.2 Specific Gravity( <i>G<sub>mb</sub></i> ) calculation	30
3.3.3 Specific Gravity ( <i>G<sub>mb</sub></i> ) determination for quarry dust	31
3.3.4 Samples preparation for quarry dust	31
3.3.5 Specific Gravity calculation for Quarry dust	32
3.4 Marshall Method of Mix Design (ASTDM D 1559)	32
3.4.1 Outline of method	32
3.4.2 Preparation of test samples	33
3.4.3 Number of samples	35
3.4.4 Preparation of aggregates	36
3.4.5 Mixing and compaction temperature of Asphalt cement	36
3.4.6 Preparation of mold	36
3.4.7 Preparation of mixtures	36
3.4.8 Compaction of mixtures	37
3.4.9 Test procedure for samples	37
3.4.10 Apparatus for testing the test samples	38

<b>CHAPTER 3 RESEARCH METHODOLOGY</b>	<b>PAGE</b>
3.4.11 Bulk specific gravity determination	39
3.4.12 Stability and flow test	39
3.4.13 Density and void analysis	40
3.4.14 Preparation of data	41
3.4.15 Trend and relation of data	42
3.4.16 Determination of Optimum Asphalt Content	43
3.5 AASHTO T283(Resistance of Compacted Asphalt Mixtures to Moisture Damage	43
3.5.1 Samples Reconditioning	44
3.5.2 Samples Testing	47
3.5.3 Calculation of Tensile Strength	48
 <b>CHAPTER 4 RESULT AND ANALYSIS</b>	
4.1 Introduction	50
4.2 Marshall properties of sample compacted at various temperatures	52
4.2.1 Analysis of mixture density	54
4.2.2 Analysis of VTM in mixtures	55
4.2.3 Analysis of VFA in mixtures	56
4.2.4 Stability analysis	57
4.2.5 Flow analysis	58
4.2.6 Stiffness analysis	59
4.3 Result of Indirect Tensile Test	61
4.3.1 TSR result for ACW14 and ACW20	61

<b>CHAPTER 5 CONCLUSION</b>	<b>PAGE</b>
5.1 Study conclusion	63
5.2 Recommendation	64
<b>REFERENCES</b>	<b>66</b>
<b>APPENDICES</b>	<b>68-88</b>

**LIST OF TABLES**

<b>TABLE NO</b>	<b>TITLE</b>	<b>PAGE</b>
2.1	Gradation limits for ACW14 and ACW20	10
2.2	Type of moisture sensitivity test	18
2.3	JKR/SPJ/1988 specification for asphalt wearing course	20
3.1	Percentage retain in sieve for ACW14 and ACW20	27
4.1	Bulk specific gravity of aggregate and quarry dust	50
4.2	Optimum asphalt content for ACW14 and ACW20	51
4.3	Marshall properties at optimum asphalt content	52
4.4	Marshall properties of ACW14.	53
4.5	Marshall properties of ACW20	53
4.6	Indirect tensile test result for ACW14	61
4.7	Indirect tensile test result for ACW20	61

**LIST OF FIGURES**

<b>FIGURE NO</b>	<b>TITLE</b>	<b>PAGE</b>
2.1	Typical structure of molecule found in asphalt (ASTM 1997)	7
2.2	VMA, air void and effective asphalt content in Compacted asphalt paving mixture (Asphalt Institute 1988)	12
2.3	Element in moisture susceptibility of mixture (After Lu 2003)	17
2.4	Indirect tensile test during load and fail	20
3.1	Work schematic of the project	26
3.2	Aggregate dried in oven	28
3.3	Sample weight in dry condition	29
3.4	Sample weight in submersion basket	29
3.5	Compaction machine	35
3.6	Sample submerged in water bath	39
3.7	Vacuum saturation process	46
3.8	Sample freeze at temperature of $-18 \pm 3^{\circ}\text{C}$	47
3.9	Indirect tensile test	48
3.10	Failed sample	48

**LIST OF GRAPHS**

<b>GRAPH NO</b>	<b>TITLE</b>	<b>PAGE</b>
4.1	Density vs. compaction temperature	54
4.2	VTM vs. compaction temperature	55
4.3	VFA vs. compaction temperature	56
4.4	Stability vs. compaction temperature	58
4.5	Flow vs. compaction temperature	59
4.6	Stiffness vs. compaction temperature	60
4.7	TSR of ACW14 and ACW20 vs. compaction temperature	62

**LIST OF SYMBOLS**

°C	-	Celsius
°F	-	Fahrenheit
%	-	percent
μ	-	micron
mm	-	milimeter
m	-	meter
<i>G<sub>mb</sub></i>	-	bulk specific gravity
<i>G<sub>ma</sub></i>	-	apparent specific gravity
<i>V<sub>a</sub></i>	-	air void
<i>P<sub>be</sub></i>	-	effective asphalt
Π	-	pi
P	-	maximum load
t	-	thickness
kg	-	kilogram
g	-	gram
cc	-	cubic centimeter
in	-	inches
kpa	-	kilopascal
N	-	newton

## LIST OF APPENDICES

<b>APPENDIX</b>	<b>TITLE</b>	<b>PAGE</b>
A1	Aggregate gradation	68
B1	Bulk specific gravity of aggregates	69
C1	Aggregate weight for 4.5 to 6.5% Asphalt content For ACW20	70
C2	Aggregate weight for 4.5 to 6.5% Asphalt content For ACW14	71
D1	Aggregate content used in mix design of ACW14 and ACW20	72
E1	Samples produced	73
E2	Stability correlation factor	74
F1	Optimum asphalt content for ACW14	75
F2	Optimum asphalt content for ACW20	77
G1	Marshall properties of ACW14	79
G2	Marshall properties of ACW20	81
H1	TSR results for ACW14	83
H2	TSR results for ACW20	84
I1	TSR form	85
J1	Sample ACW14 after indirect tensile test	86
J2	Indirect tensile test head	89
J3	Samples fail	90

## **CHAPTER 1**

### **INTRODUCTION**

#### **1.1 Background study**

Hot mix asphalt (HMA) is one type of premix widely used in road construction worldwide. It is considered by many highway engineers as premier paving product available anywhere at any cost and the most popular as paving material with high skid resistance, high comfort ability and low maintenance cost. HMA paving consist of a combination of aggregate uniformly mixed and coated with asphalt cement. Term of “hot mix” comes from aggregate and asphalt cement dried and heated for proper mixing and workability and mix together with desired temperature.

The aggregate and asphalt will be combined in an asphalt mixing plant in which it will be proportioned, heated, and mixed to produce the desired paving mixture. After the plant mixing is complete, the mix will be transported to site and spread with paving machine in loosely compacted layer to uniform , smooth surface. Then the mix will be compacted by heavy roller to produce smooth and well consolidated course.

Compaction is one of major issue in HMA and important criteria in process to produce good quality of hot mix asphalt. Temperature controls asphalt cement viscosity which affect its ability to coat and provide adequate lubrication for aggregates and slides with each other and pack into dense mass during compaction.

The effects of compaction temperature can be subdivided with respect to density and engineering properties. In procedure of pavement construction the compaction is done when temperature reach 110°C (refer to JKR specification) and in laboratory HMA normally compacted when temperature reach 145 °C.

However, there is a trend nowadays to operate asphalt plant at lower mixing temperature. Mixing at lower temperature result primarily for one major reason to conserve energy required producing the mixture. Lower mixing temperature means lower operating cost. These lower temperatures commonly result of the introduction of drum mixer that requires less energy for the production of asphalt mixtures.

At site the lower compaction temperature caused by transportation of mix, weather and other factor that cannot be minimized. Many studies have been conducted abroad but it covers small range of temperature and it cannot be related to Malaysia.

Besides compaction, the other major concern is the moisture especially water presence in the mix that may cause tremendous problem to the asphalt performance. The moisture damage will reduce the adhesion between aggregate and asphalt cement. This problem called stripping and normally it cause the HMA to have another deterioration problem such as raveling, rutting and segregation.

There are many type of test to determine the moisture susceptibility of HMA. It can be divided into two groups namely test on compacted and test on loose

mixture. The modified Loftman was among the most reliable test used by many researchers in process of predicting the moisture damage of compacted mix.

The other important criterion of hot mix asphalt is design methodology. The early design of asphalt mixture was performed without any sense related to performance such as strength and durability. Things change as the revolutions of effort to improve performance by developing new principles and concept with careful attention to material and function in the mixture.

This study has its major contribution to the problem related to the various compaction temperatures in the field and presence of moisture in mix. So from this study, relevant countermeasures to the problem arise from HMA compacted at different temperature can be made.

## **1.2 Objective of the study**

The purpose of this study is to determine the Marshall properties of HMA compacted at various compacting temperature. This study also focuses on moisture susceptibility in term of moisture damage to the HMA when it is subjected to the presence.

### **1.3 Scope of the study.**

The HMA used in this study were asphalt concrete wearing course with nominal maximum size of aggregate is 14mm (ACW14) and ACW 20. Hot mix asphalt was compacted at varied temperature to determine its effect on stability and durability. Samples were compacted using 75 blow/face and design by using Marshall Design mix. Samples were analyzed in terms of density, flow, stiffness, VMA (Void in mineral), VFA (void filled with Asphalt) and stability.

Besides that this study also aims at predicting the durability of the mixes. This can be determined by finding the indirect tensile strength of compacted samples at different conditions. This test is accordance with AASHTO T283 (Resistance of compacted asphalt mixtures to moisture- induced damage). All testing were conducted at Makmal Pengangkutan, Universiti Teknologi Malaysia, Skudai, Johor.

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