

EVALUATION ON AGGREGATE EFFECTIVE SPECIFIC GRAVITY AS
RELATED TO MARSHALL VOLUMETRIC PROPERTIES

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Dedicated to

My beloved family

My best friends

My beannie..

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ABSTRACT

The volumetric properties which consist of voids in total mix (VTM), voids in the mineral aggregate (VMA) and voids filled with asphalt (VFA) of compacted hot mix asphalt (HMA) provide an indication of the potential pavement mixture performance. Usually, the voids in compacted HMA were calculated on the basis of bulk specific gravity of the aggregate assuming that there is no asphalt absorbed in the aggregate permeable pores. In the case of asphalt absorption, the use of aggregate effective specific gravity should give a more true value of voids in compacted HMA. This study was carried out to determine the voids value of compacted HMA on the basis of effective specific gravity of the aggregate. Comparisons of the voids value using both specific gravities were analysed in terms of optimum asphalt content (OAC) and volumetric properties determination. The results show that OAC, VMA, VFA and stability of the mix increase on the basis of aggregate effective specific gravity.

ABSTRAK

Ciri – ciri volumetrik yang terdiri daripada lompong dalam campuran (VTM), lompong dalam agregat (VMA) dan lompong terisi simen asphalt (VFA) bagi campuran panas asphalt (HMA) padat adalah faktor penting untuk menentukan prestasi campuran jalan raya. Kebiasaannya, lompong di dalam campuran panas asphalt padat dianalisis berdasarkan graviti tentu pukal agregat, dengan anggapan bahawa tiada simen asphalt yang diserap ke dalam liang telap agregat. Namun begitu dalam mengambil kira penyerapan asphalt, penggunaan graviti tentu efektif seharusnya memberikan nilai sebenar lompong di dalam campuran panas asphalt padat. Kajian ini dijalankan untuk menentukan nilai lompong di dalam campuran panas asphalt padat dianalisis berdasarkan graviti tentu efektif agregat. Perbandingan nilai lompong yang dianalisis menggunakan kedua – dua graviti tentu ini dilihat dari penentuan kandungan asphalt optimum dan ciri – ciri volumetrik. Keputusan daripada kajian yang dijalankan menunjukkan kandungan asphalt optimum, VMA, VFA dan kestabilan campuran adalah lebih tinggi berdasarkan graviti tentu efektif agregat.

TABLE OF CONTENTS

CHAPTER	TITLE	PAGE
	DECLARATION	ii
	DEDICATION	iii
	ACKNOWLEDGEMENT	iv
	ABSTRACT	v
	ABSTRAK	vi
	TABLE OF CONTENTS	vii
	LIST OF TABLES	x
	LIST OF FIGURES	xii
	LIST OF SYMBOLS / ABBREVIATIONS	xiv
	LIST OF APPENDICES	xv
1	INTRODUCTION	
	1.1 Research Background	1
	1.2 Problem Statement	2
	1.3 Objective	3
	1.4 Scope	3
	1.5 Significance of Research	3
2	LITERATURE REVIEW	4
	2.1 Hot Mix Asphalt Mixture	4
	2.2 Aggregate	5
	2.2.1 Specific Gravities	6
	2.2.2 Absorption And Porosity	9

2.3	Volumetric Properties of Asphalt Mixtures	11
2.3.1	Air voids	12
2.3.2	Voids in the Mineral Aggregate	14
2.3.3	Voids Filled with Asphalt	16
2.4	Asphalt Content	16
2.5	Influence of Aggregate Specific Gravity on Determination of Volumetric Properties	19
2.6	Durability and Asphalt Film Thickness of Hot Mix Asphalt	24
2.7	Marshall Mix Design Method	25
3	RESEARCH METHODOLOGY	27
3.1	Introduction	27
3.2.	Laboratory Test Procedure	28
3.2.1	Sieve Analysis of Fine and Coarse Aggregates (ASTM C 136-84a)	29
3.2.2	Specific Gravity and Absorption of Coarse Aggregate (ASTM C 127-88)	30
3.2.3	Specific Gravity and Absorption of Fine Aggregate (ASTM C 128-88)	33
3.2.4	Theoretical Maximum Specific Gravity and Density of Bituminous Paving Mixtures (ASTM D 2041-91)	35
3.2.5	Resistance to Plastic Flow of Bituminous Mixtures Using Marshall Apparatus (ASTM D 1559)	37
3.3.	Data Collection	40
3.4.	Data Analysis	40
3.4.1	Volumetric Properties of Compacted Mixtures	41
3.4.2	Optimum Asphalt Content	44
3.5	Data Presentation	45
3.6.	Specification	45

4	RESEARCH FINDINGS AND ANALYSIS	48
4.1	Introduction	48
4.2	Aggregate Gradation	48
4.3	Aggregate Bulk Specific Gravity	49
4.3.1	Bulk Specific Gravity of Coarse Aggregate	49
4.3.2	Bulk Specific Gravity of Fine Aggregate	49
4.3.3	Specific Gravity of Filler	50
4.3.4	Bulk Specific Gravity for Total Aggregate	50
4.4	Maximum Specific Gravity of Paving Mixture	51
4.5	Aggregate Effective Specific Gravity	52
4.6	Specific Gravity of Asphalt	52
4.7	Volumetric Properties Analysis	52
4.7.1	Voids in Total Mix, VTM	53
4.7.2	Voids in Mineral Aggregate, VMA	54
4.7.3	Voids Filled with Asphalt, VFA	55
4.8	Optimum Asphalt Content (OAC)	57
4.9	Stability and Flow at Optimum Asphalt Content	63
4.10	Comparison of mix properties at the optimum asphalt content evaluated on the different aggregate specific gravity	64
4.11	Comparison of mix properties with specification	64
5	CONCLUSIONS AND RECOMMENDATION	66
5.1	General	66
5.2	Conclusions	66
5.3	Recommendation	68

REFERENCES	69
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Appendices A - D	73 - 84
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LIST OF TABLES

TABLE NO.	TITLE	PAGE
2.1	Suggested Minimum and Maximum VMA	15
2.2	Influence of Type of Specific Gravity on Determination of VMA and Air Voids	19
2.3	Incorrect and Correct Voids Values for the Compacted Paving Mixture	20
2.4	The effect of variations in specific gravity on air voids	22
3.1	Gradation Limits and Binder Contents for Bituminous Macadam	46
3.2	Gradation Limits for Asphaltic Concrete	46
3.3	Design Bitumen Contents	47
3.4	Test and Analysis Parameters for Asphaltic Concrete	47
4.1	Bulk specific gravity of coarse aggregate for each mix	49
4.2	Bulk specific gravity of fine aggregate for each mix	50
4.3	Bulk specific gravity of total aggregate for each mix	50
4.4	Maximum Specific Gravity for each mix	51
4.5	Maximum Specific Gravity at each asphalt content	51
4.6	Effective specific gravity for each mix	52
4.7(a)	VTM (%) at each asphalt content for ACW 14	53
4.7(b)	VTM (%) at each asphalt content for ACW 20	53
4.7(c)	VTM (%) at each asphalt content for ACB 28	54
4.8(a)	VMA (%) at each asphalt content for ACW 14	54
4.8(b)	VMA(%) at each asphalt content for ACW 20	55
4.8(c)	VMA (%) at each asphalt content for ACB 28	55

4.9(a)	VFA (%) at each asphalt content for ACW 14	56
4.9(b)	VFA (%) at each asphalt content for ACW 20	56
4.9(c)	VFA (%) at each asphalt content for ACB 28	56
4.10	Stability and flow of asphaltic concrete (AC) at optimum asphalt content	63
4.11	Stability and flow of bituminous macadam (BM) at optimum asphalt content	63
4.12	Mix properties of asphaltic concrete (AC) at optimum asphalt content	64
4.13(a)	Mix properties of ACW 14 at optimum asphalt content	65
4.13(b)	Mix properties of ACW 20 at optimum asphalt content	65
4.13(c)	Mix properties of ACB 28 at optimum asphalt content	65

LIST OF FIGURES

FIGURE NO.	TITLE	PAGE
2.1	Apparent Specific Gravity (Roberts <i>et al.</i> , 1996)	7
2.2	Bulk Specific Gravity (Roberts <i>et al.</i> , 1996)	7
2.3	Effective Specific Gravity (Roberts <i>et al.</i> , 1996)	8
2.4	Illustrating VMA, air voids and effective asphalt content in compacted asphalt paving mixture (Asphalt Institute, 1988).	11
2.5	Maximum Theoretical Specific Gravity	13
2.6	Bulk Specific Gravity of Mixture	14
2.7	Illustration of Asphalt Film Thickness (Chadbourn <i>et al.</i> , 2000)	25
3.1	Flow Chart for Experiment Design	28
3.2	Sieves from pan to 20 mm	30
3.3	The ASTM D 2041 test apparatus	36
3.4	The specimens submerged in the water bath	39
3.5	The complete assembly to be placed on Compression Testing Machine	39
3.6	Compression Testing Machine	39
4.1(a)	Optimum asphalt content determination for ACW 14	57
4.1(b)	Optimum asphalt content determination for ACW 20	58
4.1(c)	Optimum asphalt content determination for ACB 28	58
4.1(d)	Optimum asphalt content determined by bulk and effective specific gravity	59

4.2(a)	VMA (%) at optimum asphalt content for ACW 14	60
4.2(b)	VMA (%) at optimum asphalt content for ACW 20	60
4.2(c)	VMA (%) at optimum asphalt content for ACB 28	61
4.3(a)	VFA (%) at optimum asphalt content for ACW 14	61
4.3(b)	VFA (%) at optimum asphalt content for ACW 20	62
4.3(c)	VFA (%) at optimum asphalt content for ACB 28	62

LIST OF SYMBOLS / ABBREVIATIONS

AAMAS	-	Asphalt-Aggregate Mixture Analysis System
AASHTO	-	American Association of State Highway and Transportation Officials
ACB	-	Asphaltic Concrete Binder Course
ACW	-	Asphaltic Concrete Wearing Course
ASTM	-	American Society for Testing and Materials
BMR	-	Bituminous Macadam Roadbase
BMW	-	Bituminous Macadam Wearing Course
G_{mb}	-	Bulk Specific Gravity of Compacted Mixture
G_{mm}	-	Maximum Specific Gravity of Paving Mixture
G_{sa}	-	Apparent Specific Gravity of Aggregate
G_{sb}	-	Bulk Specific Gravity of Aggregate
G_{se}	-	Effective Specific Gravity of Aggregate
HMA	-	Hot Mix Asphalt
JKR	-	Jabatan Kerja Raya
NAPA	-	National Asphalt Pavement Association
OAC	-	Optimum Asphalt Content
P_b	-	percent of asphalt by total weight of mixture
P_{mm}	-	total loose mixture, percent by total weight of mixture
P_s	-	percent of aggregate by total weight of mixture
SSD	-	Saturated Surface Dry
US	-	United States of America
UTM	-	Universiti Teknologi Malaysia
VFA	-	Voids Filled with Asphalt
VMA	-	Voids in the Mineral Aggregate
VTM	-	Voids in Total Mix

LIST OF APPENDICES

APPENDIX	TITLE	PAGE
A	Aggregate Gradation	73
B	Aggregate Bulk Specific Gravity	76
C	Maximum Specific Gravity of Loose Mixture	82
D	Bulk Specific Gravity of Compacted Mixture	84

CHAPTER I

INTRODUCTION

1.1 Research Background

The volumetric properties which consist of air voids or voids in total mix (VTM), voids in the mineral aggregate (VMA) and voids filled with asphalt (VFA) are important parameters evaluated in hot mix asphalt (HMA) mix design which provide an indication of the potential mixture's pavement performance. The volumetric properties of the compacted HMA are determined at the laboratory design stage and used in the two laboratory design procedures, Marshall and SuperPave.

The air voids in compacted HMA consists of small air spaces between the asphalt binder coated aggregate particles. The term VMA describes that portion of the space in a compacted HMA pavement or specimen which is not occupied by the aggregate (Kandhal and Chakraborty, 1996) and the VFA are the VMA that is filled with asphalt binder.

Establishing an adequate VMA during mix design and in the field will help establish adequate film thickness without excessive asphalt bleeding or flushing (Chadbourn *et al.*, 2000), hence provide a durable asphalt mixture. The air voids in the total compacted mix also need to be sufficient enough to allow for a slight amount of additional compaction under traffic loading without flushing, bleeding, and loss stability, yet low enough to keep out harmful air and moisture (Asphalt Institute, 1988).

The specific gravity of an aggregate is needed in calculating the voids in a compacted HMA. There are three different types of aggregate specific gravities used in the voids analysis of compacted HMA: apparent, bulk and effective. This study was carried out to determine the volumetric properties of a compacted HMA on the basis of aggregate effective specific gravity.

1.2 Problem Statement

The selection of specific gravity of the aggregate to be used in mix design calculation can give different values on calculated voids in the compacted HMA. According to Asphalt Institute, the VMA of a compacted HMA is most appropriately calculated on the basis of the bulk specific gravity of the aggregate. It is assumed that there is no asphalt cement absorbed into the aggregate permeable pores. However, all mineral aggregate have the potential to absorb asphalt binder.

Aggregate with large permeable pores will reduce effective asphalt content because the portion of the asphalt that is absorbed is no longer available as binder (Chadbourn *et al.*, 2000). By not taking asphalt absorption into account cause the VMA to be underestimated, resulted in a lower film thickness which can lead to mixture durability problem.

A present in Malaysia, the voids in compacted HMA are calculated based upon bulk specific gravity of aggregate with no allowance for asphalt absorbed into the aggregate. The concept of effective specific gravity more truly describes the case of asphalt absorption when calculating the voids in a compacted HMA mixture (Roberts *et al.*, 1996). From this research, the correct value for voids in compacted HMA can be verified.

1.3 Objective

This study is undertaken to compare the Marshall volumetric properties value of compacted HMA based upon effective and bulk specific gravity of the aggregate.

1.4 Scope

In order to achieve the objective, this project mainly dealt with laboratory testing involving aggregate and HMA mixture. There were six different mixes utilized namely ACW14, ACW20, ACB 28, BMW14, BMW20 and BMR 28. The tests were performed at Highway & Transportation Laboratory, UTM. The analysis on volumetric properties was conducted and conclusion is included in the report.

1.5 Significance of Research

From this project, the Marshall volumetric properties of compacted HMA evaluated on the basis of effective specific gravity of the aggregate can be determined. The volumetric properties evaluated on the basis of effective specific gravity will be compared to the volumetric properties evaluated on the basis of bulk specific gravity of the aggregate. This research finding hopefully can serve as a guideline for highway engineer in considering aggregate effective specific gravity as an alternative in determination of volumetric properties of a compacted HMA.

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