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

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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

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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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