EVALUATION ON PROPERTIES OF TENDER MIXES

ZANARIAH BT ABD RAHMAN

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Faculty of Civil Engineering
Universiti Teknologi Malaysia

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ABSTRACT

Tender mix has caused many problems to the contractor during the construction of hot mix asphalt (HMA) pavement. The objective of this paper was to investigate the properties of tender mixes as related to the problem of rutting. Two mixes of ACW20 were designed in compliance to Jabatan Kerja Raya (JKR) specification. One mix was designed with typical dense graded gradation but away from the maximum density line (MDL) described as control mix. The other mix was designed close to MDL to simulate tender mix. Marshall sample were prepared in order to determine the optimum bitumen content (OBC) and volumetric properties of compacted mixtures. Using the OBC obtained from Marshall samples, two beams were fabricated for each mix for the wheel-tracking test. Comparisons of rut depth between control mix and tender mix were made at 500, 1000, 2000 and 5000 passes. Volumetric properties results indicate that 'tender mix' is not tender as expected due to high voids in the mineral aggregate (VMA) compared to control mix. However, there is a significant difference between tender mix and control mix in terms of rutting according to the t-Test statistical analysis. Furthermore, tender mix indicated low stability and stiffness value which show that the gradation of tender mix that was designed close to MDL are recommended as poor gradation and show a potential problem in mixes if the mix is used.

ABSTRAK

Campuran lembut telah menimbulkan banyak masalah kepada kontraktor jalan raya semasa proses turapan campuran berasfalt panas (HMA). Objektif bagi kajian ini ialah untuk menilai ciri-ciri volumetrik yang pada campuran lembut dan dikaitkan dengan masalah aluran. Dua campuran ACW20 telah direka dengan mematuhi keperluan spesifikasi dari Jabatan Kerja Raya (JKR). Satu rekaan campuran mempunyai gradasi gred tumpat yang tipikal tetapi menjauhi garisan ketumpatan maksimum (MDL) dan dikenali sebagai campuran kawalan manakala satu rekaan campuran yang lain mempunyai gradasi yang direka hampir dengan MDL dan dikenali sebagai campuran lembut. Sampel Marshall disediakan untuk mendapatkan kandungan bitumin optimum (OBC) dan ciri-ciri volumetrik bagi setiap campuran. Dengan menggunakan kandungan bitumen optimum yang telah diperolehi, dua sampel rasuk disediakan untuk campuran kawalan dan campuran lembut sebagai sampel untuk digunakan dalam ujian jejak roda. Perbandingan bagi kedalaman aluran antara dua campuran tersebut akan dilakukan pada 500, 1000, 2000 dan 5000 laluan. Daripada keputusan ciri-ciri volumetrik, didapati bahawa lompang dalam agregat (VMA) bagi campuran lembut menunjukkan nilai yang tidak dijangka iaitu nilai VMA campuran lembut lebih tinggi berbanding nilai VMA campuran kawalan. Walaubagaimanapun, terdapat perbezaan yang ketara dalam nilai kedalaman aluran antara campuran kawalan dan campuran lembut berdasarkan daripada analisis statistik t-Test. Tambahan pula, campuran lembut juga menunjukkan nilai kestabilan dan kekukuhan yang rendah dan dengan ini gradasi bagi campuran lembut yang direka berhampiran dengan MDL dicadangkan sebagai gradasi yang tidak sesuai digunakan kerana berpotensi untuk menimbulkan masalah jika campuran digunakan kelak.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS / ABBREVIATIONS

AASHTO	-	American Association of State Highway and Transportation Officials
ACW	-	Asphaltic Concrete Wearing Course
AI	-	Asphalt Institute
ASTM	-	American Society for Testing and Materials
FHWA	-	Federal Highway Administration
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
MDL	-	Maximum Density Line
NAPA	-	National Asphalt Pavement Association
OBC	-	Optimum Bitumen Content
OPC	-	Ordinary Portland Cement
P_{mm}	-	total loose mixture, percent by total weight of mixture
P_s	-	percent of aggregate by total mass of mixture
Superpave	-	Superior Performing of Asphalt Pavement
UK	-	United Kingdom
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

CHAPTER 1

INTRODUCTION

1.1 Research Background

There are two types of tenderness as reported by Crawford (1989). The first type is characterized by the asphalt mix being difficult to compact when normal construction techniques are used. Re-compaction attempts will result in a decrease in pavement density. The other type of tenderness is characterized by the asphalt mixtures being slow setting after construction. This type is sensitive to turning traffic and power steering. It may also lack resistance to critical loading, especially during hot weather.

The problem of compaction of tender mixes is actually has been observed for years by United States. Tender mixtures are not stable under the roller and tend to move laterally when rolled. This lateral movement sometimes result in hairline crack. Hairline cracks that sometimes results when rolling tender mixes are usually very shallow and do not cause a significant problem. However, these cracks allow the mix to absorb moisture and may reduce the durability of the hot mix asphalt (HMA). They may provide a weakness in the HMA pavement that may result in crack growth and eventually premature failure. In the past year, most tender mixes were attributed to excessive temperatures or excessive sanded mixes. There are many other possible reasons for the tender mixes but these two causes appeared to be mentioned most (Brown *et al*., 2000).

The complaints about tender or slow setting asphalt pavements in the United States always arise at about the same time of year which is from about the first part of July through the middle of September (Tarrer and Wagh, 1991). At this time of year, ambient temperatures are high. Tender pavement rarely occurred in cool weather therefore it seems obvious that one of the conditions that must be obtained for this type of distress is hot weather. Furthermore, Hot Mix Asphalt Paving Handbook (2000) shows that gradation that close to the maximum density line (MDL) may have at times lower than desirable Voids in the Mineral Aggregates (VMA) which will result in very little void space within to developed sufficient asphalt thickness for durable mix. It is also recommended that such gradation to be avoided so as not to produce mixes that are tender and difficult to compact

Brown *et al.* (2000) reported that in the early to mid 1990s, Superpave mixes began to be used in the United States. For the most part, these mixes have been coarse-graded mixes with relatively high coarse aggregate content. Experience has shown that when these mixes are tender, they act similar to tender mixes that were encountered in the past. Based on two surveys by National Asphalt Pavement Association (NAPA), it appears that approximately 40 percent of coarse graded Superpave mixes experience some tenderness (Brown *et al*., 2000). Therefore, as a result of reported tenderness problems, the Federal Highway Administration (FHWA) and NAPA held a jointly meeting in June 1998. There was a lot of discussion about causes and cures of the tender mix problem among the attendees which included state Department of Transportations (DOTs) and Industry representatives (Brown *et al.*, 2000). This shows that FHWA and NAPA are concern about the problems created from tender mixes and is looking forward to improve the mixes.

1.2 Problem Statement

Tarrer and Wagh (1991) reported that tender mixes are often difficult to compact to the required density. Once the mix begins to move laterally, additionally rolling results in further lateral movement and does not allow for adequate compaction. Even though these tender mixes may not result in loss of life, they will lower the overall pavement quality by increasing the roughness of the compacted mixes. In general, tender mixes are difficult to roll, difficult to achieved specified density and occasionally rut. Other than that, they will also displace under high pressure and shove and scuff under traffic (Button *et al.*, 1980).

A remarkable increase in traffic volume has contributed to the severe rutting on highway and main road in Malaysia. Rutting is defined as the accumulation of small amounts of unrecoverable strain resulting from applied wheel loads to HMA pavement (Cooley Jr *et al.*, 2000). Rutting in HMA will not only decrease the life of pavement but also will create safety hazard to the public. Therefore, it is necessary to estimate the potential of rutting on tender mixes besides investigating the properties of tender mixes.

1.3 Objective

This study is undertaken to evaluate the properties of tender mixes as related to rutting problem.

1.4 Scope

In order to accomplish the objective, this study is subjected to this following scope and limitation:

i. Designing two (2) ACW20 mixes using Marshall design conforming to Jabatan Kerja Raya (JKR) specification;

   a. One mix design with typical dense graded gradation but away from maximum density line (MDL) described as control mix.
   b. One mix design with gradation design close to MDL to simulate tender mix.

ii. Wheel tracking machine was used to investigate the differences in rut depth between control mix and tender mix.

1.5 Importance of Study

From this project, the properties of tender mix that are design close to MDL can be determined hence providing a guideline for highway engineers to produce a high-quality pavement through well designed gradation. In relation to the properties, the suitability of the gradation to resist rutting was also be able to determined through analyzing the data and result from wheel tracking machine test.

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