

بسم الله الرحمن الرحيم

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"صدق الله العظيم"

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DEDICATION

This thesis is dedicated to my family for their help and patience during my preparation of this thesis.

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Abstract

Load-induced pavement fatigue damage and rutting have become problematic on several road national pavements that are subjected to heavy static and dynamic traffic loads. The need for accurate and consistent laboratory tests of the volumetric properties of the hot mix asphalt (HMA) has become increasingly important in recent years. The objective of this study was to evaluate the effects of the Superpave defined restricted zone on HMA performance and determine the resulting improvements in pavement performance due to addition of hydrated lime and Portland cement to HMA mixes. To study these effects, a set of experiments included one gradation that violated (through) the restricted zone (TRZ), two gradations below the restricted zone (BRZ), and one gradation above the restricted zone (ARZ) with one type of binder. These were subjected to Marshall tests, analysis, and evaluation. From the analysis, it was found that mixes having gradations violating (TRZ) and passing above the restricted zone (ARZ) performed better than the mixes with gradations below the restricted zone (BRZ) with respect to laboratory tests. This conclusion was drawn from the results of experiments using 19.0 mm maximum aggregate size gradations and 75-blow design. The aggregates used were crushed aggregates (basalt) with different sizes, natural sand, and natural filler. One type of asphalt cement was used with 40-50 penetration grade and the design traffic level was taken to be greater than 10^6 EAL. Marshall test was used to evaluate HMA performance.

The results also showed mixes having gradations below the restricted zone, which was commonly recognized to be rut-resistant, have lower stability than that having gradations above or through the restricted zone.

In the second set of experiments, comparison was made between the effect of natural filler and that of hydrated lime on stability, flow, and stripping resistance. Two mixes were used, one below and the other above restricted zone. The results showed that the addition of lime increases the stripping resistance remarkably, on the other hand decreases stability, and increases flow.

In the third set of experiments, comparison was conducted between the effect of natural filler and that of Portland cement on Marshall stability and flow with mix passing above the restricted zone, using data obtained from quality control tests performed during the paving of Al-Mak Nimir Bridge in 2008. Three mix designs were used in this comparison; the first one with three percent natural filler, the second with three percent cement, and the third with five percent cement. The results showed that the addition of cement increased the stiffness of asphalt mix, increasing stability and decreasing flow.

Keywords: *Hot mix asphalt, volumetric properties, Superpave restricted zone, mineral filler Marshall Method, stability, flow, stripping resistance.*

التجريد

إن الرصف فى الاماكن ذات الجو الساخن كالسودان والتي يتعرض الرصف فيها للتخدد والرطوبة يجعله عرضة للدمار فى العديد من الطرق المعرضة للحمولات الساكنة والمتحركة. لذلك الحاجة الى الإختبارات الثابتة والدقيقة للحصول على الخواص الحجمية للخلطة الأسفلتية الحارة اصبحت مهمة بشكل متزايد فى السنوات الأخيرة. فالهدف من هذه الدراسة هو تقييم أثر منحنيات سوبريفف و المنطقة المقيدة على أداء الخلطة الاسفلتية وتحديد التحسينات الناتجة للخلطة من إضافة الجير و الأسمنت. وقد تمت دراسة هذه التأثيرات بثلاثة إختبارات. الاول يتضمن مقارنة تدرج مار بالمنطقة المحظورة مع تدرجين أسفل المنطقة المحظورة وتدرج أعلى المنطقة المحظورة وذلك بإستخدام نوع واحد من البيتومين لتشكيل خلطات تم دمكها بجهاز مارشال. لقد أظهرت النتائج أن الخلطات التى تمر خلال أو أعلى المنطقة المحظورة ذات نتائج افضل من الخلطات التى تمر أسفل المنطقة المحظورة من تحليل نتائج الإختبارات العملية. فقد تم الحصول على هذه النتائج باستخدام خلطات الحجم الأقصى للركام مقداره 19 ملمتر ودمك مارشال بعدد 75 ضربة. تم إستخدام نوع واحد من الأسفلت بدرجة إختراق 40-50 وحجم مرور تصميمى اكبر من 10^6 . أوضحت النتائج أن الخلطات التى يمر تدرجها أسفل المنطقة المحظورة والتى من المفترض أن تكون اكثر مقاومة للتخدد لها قيم ثبات أقل من الخلطات التى تمر أعلى أو خلال المنطقة المحظورة.

فى الجزء الثانى من البحث تم إجراء مقارنة بين استخدام البدرة الطبيعية والجير فى الثبات والانسياب ومقاومة الإنسلاخ وذلك باستخدام خلطات واحدة أسفل المنطقة المحظورة والاخرى أعلى المنطقة المحظورة. لقد أظهرت النتائج أن إضافة الجير بدلاً عن البدرة الطبيعية قللت الثبات وزادت الانسياب، لكنها ايضا زادت مقاومة الإنسلاخ.

فى الجزء الثالث من البحث تم إجراء مقارنة بين استخدام الأسمنت والبدرة الطبيعية فى الثبات والانسياب وذلك بإستخدام خلطة تم تصميمها لرصف كبرى المك نمر وذلك باستخدام 3% بدرة طبيعية، 3% أسمنت، و 5% أسمنت . أوضحت النتائج أن إضافة الأسمنت تزيد من صلابة الخلطة الأسفلتية بزيادة الثبات وتقليل الانسياب.

الكلمات الدالة: خلطة اسفلتية ساخنة، خصائص حجمية، منطقة سوبريفف المحظورة، البدرة الناعمة، طريقة مارشال، الثبات، الانسياب، مقاومة التسليخ.

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List of Abbreviations

AASHTO: American Association of Highway and Transportation Officials

ASTM: American Society for Testing and Materials

ESAL: Equivalent Single Axial Load

ETG: Aggregate Expert Task Group

FHWA: Federal Highway Administration

G_{sa} : Apparent Specific Gravity

G_{sb} : Bulk Specific Gravity

G_{se} : Effective Specific Gravity

G_{mm} : Maximum Theoretical Specific Gravity

HMA: Hot Mix Asphalt

N_{design} : Design number of gyrations

$N_{initial}$: Initial number of gyrations

N_{max} : Maximum number of gyrations

PG: Performance Grade

SHRP: Strategic Highway Research Program

Superpave: Superior Performing Asphalt Pavement

V_a : Voids in the Total Mix

V_{ba} : Volume of Absorbed Binder

VFA: Voids Filled with Asphalt

VMA: Voids in the Mineral Aggregate