PERFORMANCE OF ASPHALTIC CONCRETE INCORPORATING SBR SUBJECTED TO AGING

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Specially Dedicated To…

My Inspiration

My Parents (MOHAMMED MOHAMMED SALAH and HAMAMH QAID) and all my family members

My Supervisor

DR. RAMADHANSYAH PUTRA JAYA for his guidance

My Co-supervisor

DR. AZMAN BIN MOHAMED for his guidance

All my friends who helped me

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ABSTRACT

The influence of styrene butadiene rubber (SBR) on asphaltic concrete properties at different aging condition presented in this study. These aging conditions are named as un-aging, short-term and long-term. The conventional asphalt binder of penetration grade 60/70 was used within this work, modified with styrene butadiene rubber (SBR) at four different modification levels namely 0%, 1%, 3%, and 5% by weight binder. Asphalt concrete mixes were prepared at selected optimum asphalt content (5.0%) and then tested to evaluate their mechanical properties which include Marshall stability, resilient modulus and dynamic creep tests. From the experimental results, the findings showed that the mixes modified with SBR polymer have an improved stability and permanent deformation characteristics under aging conditions. The result also showed that the stability, resilient modulus and dynamic creep tests under long term aging is the highest among than that of the short term and un-aged. The use of 5 percent SBR has added to local knowledge the ability to produce more durable asphalt concrete mixtures with better serviceability.

Keywords: styrene butadiene rubber, aging, stability, creep resilient modulus

ABSTRAK

Kajian ini berkaitan pengaruh styrene butadiene rubber (SBR) terhadap sifat-sifat konkrit asfalt pada keadaan penuaan yang berbeza. Keadaan penuaan ini dinamakan sebagai anti penuaan, jangka masa pendek dan jangka masa panjang. Pengikat konvensional asfalt daripada penusukan gred 60/70 telah digunakan di dalam kajian ini. SBR telah diubahsuai kepada empat tahap pengubahsuaian yang berbeza iaitu 0%, 1%, 3%, dan 5% dengan menggunakan pengikat berat. Campuran konkrit asfalt disediakan apabila kandungan optimum asfalt (5.0%) telah ditentukan , kemudian ia diuji untuk menentukan sifat-sifat mekanikalnya termasuk kestabilan Marshall, modulus kebingkasan dan ujian rayapan dinamik. Hasil keputusan kajian menunjukkan, campuran yang diubahsuai dengan polimer SBR mempunyai kestabilan yang lebih baik dan ciri-ciri ubah bentuk yang kekal di bawah keadaan penuaan. Keputusan tersebut juga menunjukkan bahawa kestabilan, modulus kebingkasan dan ujian rayapan dinamik adalah yang tertinggi pada jangka masa panjang jika di berbandingkan jangka masa pendek dan anti penuaan. Penggunaan 5 peratus daripada SBR adalah nilai tambah kepada pengetahuan umum tentang keupayaannya untuk menghasilkan campuran konkrit asfalt yang lebih tahan lama dengan keupayaan perkhidmatan yang lebih baik.

Kata kunci*: Bitumen, SBR, penuaan, kestabilan, modulus kebingkasan.*

TABLE OF CONTENT

LIST OF APPENDICES

LIST OF ABBREVIATIONS

AASHTO	-	American Association of State Highway and
AC	-	Rock Quality Designed
AC14	-	Asphaltic Concrete Wearing With 14mm Nominal
ASTM	-	American Society for Testing and Materials
EVA	-	Ethylene Vinyl Acetate
g	-	gram
HMA	-	Hot Mix Asphalt
JKR	-	Jabatan Kerja Raya
JKR	-	Rock Mass Rating
LTA	-	Long Term Aging
mm	-	millimeter
MS	-	Malaysian Standard
OBC	-	Optimum Bitumen Content
PMA	-	Polymer Modified Asphalt
PMB	-	Polymer Modified Binder
SBR	-	styrene butadiene rubber
SBR	-	Styrene Butadiene Rubber
SBS	-	Styrene Butadiene Styrene
SSS	-	Slope at steady state
STA	-	Short Term Aging
TMD	-	Theoretical Maximum Density
UTM	-	Rock Mass Quality
VFB	-	Void Filled Bitumen
VTM	-	Void Ratio in Mix
σ	-	Is the applied stress, in kilopascal (kPa);
CSM	-	is the creep stiffness modulus.

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1

INTRODUCTION

1.1 Background

Asphaltic concrete is widely used in many applications, but the most important use is related to the paving industry. Asphalt is an organic mixture that is widely used in road pavement due to its good viscoelastic properties; it has many different names such as bitumen, asphalt, liquid asphalt, asphalt cement, asphalt binder and binder, but means basically the same. Increase traffic factors such as heavy tracks, higher traffic volume, and higher tire pressure will decrease the age of pavement. In addition, the temperature changes affect the performance of asphalt which result a brittle asphalt in low temperature that cause to cracking of pavement and tend to be liquid in high temperature which cause pavement rutting. Therefore to enhance the aggregate performance, it is necessary to incorporate the asphalt with polymer modifiers which mean to modify asphalt by adding polymer modifiers to improve the asphalt mechanical properties. It is very important to mix the asphalt with a polymer because it gives homogeneous materials which can attain the performance demand (Ruan, 2003).

Aging of bituminous binders in asphalt mixtures is well studied because of its effect on the mechanical performance of the binder and the durability of the asphalt pavement. The bituminous binder aging is one of the main factors to determine the lifetime of asphalt pavement, in general, the aging of bitumen takes place in two stages namely the long-term aging process evolves with time where the asphalt is exposed to the environment as in-service pavement at a relatively lower temperature for a long duration and short-term aging at high temperature during asphalt mixing, storage, and laying. Aging plays as an important factor to affect the performance of asphaltic concrete (Ahmed et al., 2008).

Today's increasing loads, greater traffic volume and the need for better, longer lasting roads demand better service from paving materials. Asphalt modified with SBR Polymers offer the best method of improving binders for highway, street and airport paving and maintenance projects. Styrene-butadiene rubber (SBR), a general-purpose synthetic rubber, produced from a copolymer of styrene and butadiene. Styrene butadiene rubber (SBR) also can be defined as a polymer used in the manufacture of expanded rubber. It is particular advantages include excellent abrasion resistance, crack resistance, and generally better aging characteristics. SBR rubber has good mechanical properties with the added advantage of better resistance to high temperatures and aging. It has further been determined that styrene butadiene rubber (SBR) is compatible with virtually all types of asphalt and have extremely high levels of force ductility, tenacity, and toughness (Hu, 2013).

1.2 Problem Statement

The road network and highway usually designed with a lifespan of 10 years or 20 years, but the damages on the pavement occur earlier than expected. Among the major factors contributing to these damages is the increasing number of vehicles and the traffic axle load significantly. In addition, the weather phenomena such as heavy rainfall also contribute to the damage of pavement, as a result, various forms of damages rutting, potholes, cracking, raveling and shoving occur.

The increased traffic densities, increased loads and axle pressure, shortage of good quality aggregates and the effect of high and low temperatures contributes to the pavements distress. The use of styrene-butadiene rubber (SBR) prevent these distress from taking place and improve the aging characteristics of the binder so that the deleterious impact of oxidative aging delayed, leading to more durable and stable pavement and help to reduce the tendency of the pavement ravel once it has aged.

After construction, pavement interface with rainfall, traffic load vehicles and other condition which shortage the lifetime of pavement and lead many damages to the road that cause accidents to the road users. There are many ways to prevent the damages on roads and enhance the performance of asphaltic concrete such as maintenance, but it costs too much. Making pavement design longer requires some additives to bitumen. Styrene-butadiene rubber (SBR) consider as one of the best additives that increase the lifetime of pavement.

1.3 Aim and Objectives of Study

The aim of this study is to make sure that bitumen is durable and resistant to changes over time. Therefore, the main objectives of this project are the following:

1) To study the influence of SBR modified bitumen on asphaltic concrete properties.
2) To investigate the performance of asphaltic concrete containing SBR at different aging conditions.

1.4 Scope of Study

The scope of this study focused on the performance of asphaltic concrete incorporating styrene-butadiene rubber (SBR) subjected to aging. The bitumen used is 60-70 PEN. The tests included are Stability, Resilient Modulus and Creep tests for both unmodified and modified bitumen. The percentage of styrene-butadiene rubber (SBR) that was added in modifying asphalt mix are 0%, 1%, 3 % and 5% by the total weight of the aggregate. The gradation used (AC14).

All tests and laboratory work were performed at Highway and Transportation Laboratory, University Technology Malaysia (UTM).

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