MODIFICATION OF ASPHALT BINDER WITH VARIOUS PERCENTAGES OF CRUMB RUBBER IN FLEXIBLE PAVEMENT

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Dedicated to my beloved parents, wife and friends

For their support

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ABSTRACT

The scrap tires (crumb rubber) are being consumed every year, and these waste tires are generating environmental issue and causing health hazard due to burning this waste and increase the landfill space. The aim of the study is to use of crumb rubber in asphalt binder mix with penetration grade 80-100 and performance grade PG76. The asphalt binders were blended with waste crumb rubber in powder form 40 mesh (0.425 micron) using wet process. The study focused on the crumb rubber as partial replacement by (15, 20 and 25%) of total weight of modified asphalt binder mix. The laboratory works were based on American Society for Testing and Materials (ASTM) and (JKR/SPJ/2008-S4) standard of Malaysia, Several tests was conducted such as Penetration, Softening point, Viscosity, Rolling Thin Film Oven and Pressure Aging Vessel tests modified asphalt binder. The result shows positive effect in which the penetration decreases as the partial replacement of crumb rubber is increased 80-100 and PG76 blend asphalt binder. However, the PG76 asphalt binder result shows lower penetration in both short term and long term aging compared to 80-100 asphalt binder in term of stiffness. The results of softening point test show that percentage of replacement of asphalt binder with crumb rubber increases the temperature of 80-100 and PG76 asphalt binder mix, especially after short term aging (RTFOT) test of PG76 at 20% replacement the temperature reached 85°C and decreased after long term aging (PAV) test to 75°C. However, with partial replacement of asphalt binder with crumb rubber indicates resistance to higher temperature susceptibility. The viscosity test results conclude that the PG76 asphalt binder has higher viscosity compared to original PG76 and 80-100 asphalt binder replacement with crumb rubber mix. The PG76 asphalt binder indicates the 20% is the optimum crumb rubber replacement for short term aging (RTFOT) test. In the long term aging (PAV) test, the viscosity reduced compared with (RTFOT) test.

ABSTRAK

Tayar sekerap (serbuk getah) telah dihasilakn setiap tahun, dan sisa tayar ini telah memberi kesah terhadap persekitaran dan membahayakan kesihatan disebabkan oleh pembakaran sisa dan peningkatkan ruang tapak pelupusan. Tujuan kajian ini adalah untuk menggunaan serbuk getah sebagai pengikat di dalam campuran asfalt campuran pengikat dengan menggunakan asphalt penusukan gred 80-100 dan gred prestasi PG76. Asfalt telah dicampur dengan sisa serbuk getah bersaiz 0.425 mikron menggunakan proses basah. Kajian ini tertumpu kepada serbuk getah sebagai pengganti asphalt sebanyak (15, 20 dan 25%) daripada berat bitumen. Kerja-kerja makmal adalah berdasarkan kepada American Society for Testing and Materials (ASTM) dan specifikasi Jabatan Kerja Raya (JKR), malaysia. Ujian yang dijalankan adalah ujian penusukan, titik lembut dan kelikatan. Peringkat kedua mensimulasikan ujian reologi melibatkan, Rolling Thin Film Oven Test (RTFOT) dan Pressure Aging Vessel test (PAV). Keputusan menunjukkan kesan positif dimana kadar penusukan berkurangan apabila penggantian serbuk getah meningkat (80-100 dan PG76 bitumen campuran). Walaubagaimanapun keputusan bitumen PG76 menunjukkan kadar penusukan yang lebih rendah terhadap kedua-dua ujian penuaan jangka pendek dan jangka panjang berbanding bitumen 80-100 dari segi ketegangan. Hasil ujian titik lembut menunjukkan bahawa peratusan penggantian bitumen dengan serbuk getah meningkatkan terhadap bitumen 80-100 dan PG76 terutamanya selepas penuaan jangka pendek (RTFOT). Suhu mencapai 85° C apabila penggantian sebuk getah sebanyak 20% kemudian menurun kepada 75 ° C selepas penuaan jangka panjang (PAV). Walaubagaimanapun, penggantian serbuk getah di dalam bitumen menunjukkan peningkatan suhu yang lebih tinggi. Penggantian campuran serbuk getah menunjukkan bitumen PG76 mempunyai kelikatan yang lebih tinggi berbanding original PG dan 80-100. Bitumen PG76 menunjukkan optimum penggantian serbuk getak adalah 20% untuk ujian penuaan jangka pendek (RTFOT). Bagi ujian penuaan jangka panjang (PAV), kelikatan berkurangkan berbanding dengan (RTFOT), boleh dikatakan secara PG76 dan 80-100 bitumen pada 25% penggantian dengan serbuk getah.

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LIST OF ABBREVIATIONS

AASHTO	-	American Association State of Highway and Transportation Officials
AR	-	Asphalt Rubber
ASTM	-	American Association for Testing and Materials
CR	-	Crumb Rubber
CRM	-	Crumb Rubber Modifier
G*	-	Complex Shear Modulus
HMA	-	Hot Mix Asphalt
JKR	-	Jabatan Kerja Raya
Pa.S	-	Pascal .Second
PAV	-	Pressure Aging Vessel
PG	-	Performance Grade
RTFOT	-	Rolling Thin Film Oven Test
δ	-	Phase Angle

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Asphalt binder is a rheological as well as polar molecular material. The modification of asphalt binder is prompted mainly by the limitation of the conventional refining practices used today in the production of asphalt binder from crude petroleum oil. Alteration by specialized refining practices, chemical reaction, and/or additives have been found to improve the contribution of asphalt binder and also to the resistance of asphalt binder in various modes or resisting pavement distress. In a recent survey of the State Highway Agencies in the United States of America (USA), a total of 35 out of 47 agencies plan to increase the use of modified binders in road construction. Twelve of the agencies were expecting to use the same amount of modified asphalt binder and some agencies they plan to reduce the amount of modified asphalt binder. The majority of the agencies have cited premature distress such as rutting and fatigue cracking as the main reason for justifying the use of modified binders (Bahia *et al*., 1997). Asphalt is extremely complex material; complete chemical analysis might be not possible (Read and Whiteoak, 2003).

Several countries in Asia, Europe, and Africa have been used recycle rubber or tires in various highways or roads applications for years ago. Although, crumb rubber conserve the material utilized as a road construction material, and minimize the landfill space that will reduce environmental impact. Many researchers, (Bahia *et al*., 1994) concluded that crumb rubber modified (CRM) binders could produce asphalt pavements with less traffic noise, less maintenance or corrective costs and improved resistance of rutting and fatigue cracking resistance.

Modified asphalt binder materials, paving products can be made with crumb rubber by several mixing or blending process including dry process. In the dry process crumb rubber blend with hot aggregate before incorporate with asphalt binder, and wet process the crumb rubber blend with asphalt binder before incorporate with aggregate.

Based on the previous research, CRM asphalt binder requires is compaction at a higher temperature than plain mixes (Amirkhanian and Corley, 2004). With lower compaction temperatures, the use of CRM mixes might result in several problems such as inadequate volumetric properties (i.e., high air voids) and poor short-term and long-term performances. Also, the viscosity increase can negatively effect on the workability of asphalt mixture and it requires the higher temperature to maintain the binder viscosity for the proper workability.

1.2 Problem Statement

The design or life span for all highways and urban roads is 10-20 years. Unfortunately, damage or distress on the pavement still occurs before reaching the maximum period of the designed road serviceability. Among the major influence factors contributing to this distress is due to repeat heavy traffic loading on the road surface. Fatigue cracks result of repeated load of causing tensile strain bottom pavement layer. Rutting of the road surface is mainly due to the buildup of compressive strain at the top of subgrade layer, that majority occurs at those countries whose higher pavement temperature, such as North Africa or South Asia countries. Several trails were made in the past to modify asphalt binder using crumb rubber to improve the performance of pavement surface for long design life.

Application of crumb rubber in Hot Mix Asphalt (HMA) is one of the uses in asphalt mix or industrial mix plant, both to improve the performance of HMA or consume the industrial waste issues.

1.3 Objectives of Study

The general objective of the study is to use waste crumb rubber with various different percentages (15, 20, and 25%) as a partial replacement of the total weight of blended asphalt binder mix using a wet process.

The specific objectives are:

1) To evaluate the physical properties of asphalt binder as a partial replacement with crumb rubber at various percentages (15, 20 and 25%) by total weight of blended asphalt binder mix.
2) To evaluate the aging performance of asphalt binder replacement with crumb rubber for short and long term aging.
3) To determine the optimum percent of crumb rubber replacement in asphalt binder mix content.

1.4 Scope of Study

The study will focus on the physical properties and performance of partial replace of asphalt binder with different percentages (15, 20 and 25%) of crumb rubber by total weight of asphalt binder mix. The asphalt binder will be using are performance grade PG-76 and penetration grade 80-100. The different sample will be prepared include the different percentage of crumb rubber in asphalt binder with different mixing temperature.

The experimental procedure will be based on American Society for Testing and Materials (ASTM) and (JKR/SPJ/2008-S4) and will be conducted in Highway and Transportation Laboratory University Technology Malaysia (UTM). Several tests will be conducted such as Penetration, Softening point, Viscosity, Rolling Thin Film Oven and Pressure Aging Vessel tests to measure the properties of CRM asphalt binder.

1.5 Significant of Study

The expected outcome of this study is the production of new developed modified asphalt binder containing crumb rubber. The CRM asphalt binder is designed to provide better riding quality and minimize the cost of pavement construction using crumb rubber as partial replacement of asphalt binder. Finally, CRM asphalt binder development will help to solve the industrial waste crumb rubber and generate green and sustainable roads and highways.

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