EFFECT OF POLYETHYLENE TEREPHTHALATE (PET) ON THE PROPERTIES OF ASPHALTIC CONCRETE

By

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This is to certify that the work of this thesis entitled “EFFECT OF POLYETHYLENE TEREPHTHALATE ON THE PROPERTIES OF ASPHALTIC CONCRETE” was carried out by Stanley Chukwuka EZEMENIKE (TP13/14/H/1330), supervised by Dr. H. Mohammed at the Department of Civil Engineering, Obafemi Awolowo University, Ile-Ife.

Supervisor’s signature and date ……………………………….

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Head of Department signature and Date …………………………………

Dr. H. Mohammed

DEDICATION

TO

My Lovely Parents

ACKNOWLEGEMENT

First of all, I give all glory to Almighty God for His mercy, favour, divine guidance, help and divine provision towards the completion of this study. I am nobody without You Lord, thank You a lot and may Your name alone by blessed forevermore (Amen).

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ABSTRACT

The study characterized the asphalt binder and polyethylene terephthalate (PET); assessed the effect of varying content of polyethylene terephthalate in asphaltic concrete and determined the optimum percentage of PET in the asphaltic concrete capable of resisting permanent deformation.

The polyethylene terephthalate was shredded into sizes between 0.6 mm to 2.36 mm with a shredding machine while physical and chemical properties of asphalt binder (bitumen) were determined to characterize them. The penetration, softening point and flash point tests were carried out on the bitumen that contained varying amount of polyethylene terephthalate. Asphaltic concrete samples were prepared using polyethylene terephthalate at 0, 2, 4, 6, 8, 10 and 12% by weight of the bitumen. The samples were subjected to marshal stability test. The values of stability, flow, density, air void (AV), void in mineral aggregate (VMA) and voids in filled with bitumen (VFB) were obtained and the effect of polyethylene terephthalate on asphaltic concrete was assessed with a view to determine the optimum percentage of polyethylene terephthalate in the asphaltic concrete.

The results showed that penetration values for bitumen-PET mixture at 0, 2, 4, 6, 8, 10 and 12 % were 63.63, 58.17, 52.07, 47.07, 39.06, 30.67 and 23.77 d-mm, while their corresponding softening point values were 47, 47.7, 48.4, 49.75, 50.55, 51.35 and 51.75˚C and flash point values of 264, 269, 272, 280, 284, 290 and 297˚C respectively. The Marshal test results for the same proportions gave stability values of 10.42, 10.84, 11.71, 14.29, 14.81, 13.12, and 10.92 kN, flow values of 3.85, 3.60, 3.38, 2.85, 2.61, 3.27 and 3.48mm, bulk density values of 2.39, 2.37, 2.32, 2.29.2.27, 2.27 and 2.25 g/m^3 , air void (AV) values of 4.47, 4.04, 3.933, 3.78, 3.404, 3.017 and

2.85 %, void in mineral aggregate (VMA) values of 18.28, 17.84, 17.44, 17.12, 16.62, 16.12 and 16.54˚C, and void filled with bitumen values of 75.83, 77.35,77.48, 77.92, 79.52, 81.28 and 82.71% respectively. The results showed` that an optimum proportion in the asphaltic concrete was achieved at 8% composition of polyethylene terephthalate.

The study concluded that the polyethylene terephthalate as additive to the bitumen improved the properties of the asphaltic concrete produced.

CHAPTER ONE

INTRODUCTION

1.1 General Background

Traditional asphalt mixtures contain liquid asphalt binder, or bitumen, and aggregate as the two principal constituents. Although the mechanical and chemical properties of the aggregates vary significantly depending on source, the overall durability and other performance characteristics of asphalt mixtures are generally limited by the performance of the asphalt binder (Somayaji, 2001).Failure of asphalt pavement due to the asphalt binder can be attributed to three primary sources. These include rutting that occurs at high temperatures as asphalt softens and the elasticity of the binder decreases, fatigue cracks from repeated loading and aging of the pavement, and low temperature cracking as the asphalt becomes brittle (Somayaji, 2001).

For the past two decades significant research has been conducted on polymer modified asphalt (PMA) mixtures. Polymers can successfully improve the performance of asphalt pavements at low, intermediate and high temperatures by increasing mixture resistance to fatigue cracking, thermal cracking and permanent deformation (Aflaki and Tabatabaee, 2008). The addition of polymers to enhance service properties over a wide range temperature in road paving applications was considered a long time ago and nowadays has become a real alternative. Addition of natural or synthetic polymers to bitumen is known to impart enhanced service properties (Aflaki and Tabatabee, 2008). By adding small amounts of polymers to bitumen, the life span of the road pavement may be considerably increased.

The purpose of bitumen modification using polymers is to Achieve desired engineering properties such as increased shear modulus and reduced plastic flow at high temperatures and/or increased resistance to thermal fracture at low temperatures and decreased permanent deformation under load (rutting). Other benefits include greater adhesion to the aggregate and increased tire traction (González *et al.*, 2006).

Improvement in rutting resistance, thermal cracking, fatigue damage, stripping, and temperature susceptibility have led polymer modified binders to be a substitute for asphalt in many paving and maintenance applications, including hot mix, cold mix, chip seals, hot and cold crack filling, patching, recycling, and slurry seal. They are used wherever extra performance and durability are desired. In many cases, they are selected to reduce life cycle costs (Yuonne and Yajara, 2001). Polymer modified binders also show improved adhesion and cohesion properties (Awwad and Shbeeb 2007).

In 1987, as part of the Superior Performing Asphalt Pavements Program (Superpave), an asphalt binder classification system that evaluated the performance properties of asphalt and classifies binders based on specified maximum and minimum service temperatures was developed. This performance grading system entails two values assigned to each asphalt grade. A high temperature grade ranging from 46 °C to 82 °C (in increments of six degrees) and a low temperature grade ranging from -10 °C to -46 °C (also in increments of six degrees) are assigned to commercially available asphalts (Somayaji, 2001). For example, PG 67-22 asphalt would have a maximum failure temperature of 67 °C and a minimum failure temperature of -22 °C. Engineers select the appropriate asphalt binder for the project based on environmental and climactic conditions for the region in which the project will be located.

Although the PG grading system provides satisfactory results in determining the appropriate asphalt binder for a construction project, it gives room for improvements that address inherent problems with asphalt binders. Studies of raw asphalt have shown that the asphalt binders can contain approximately 10% wax, depending on the source of the binder, This wax softens at high temperatures leading to reduced cohesion, strength, and stability of asphalt mixtures (Al-Hadidy and Yi-qiu Tan, 2011).

Softening of asphalt poses a problem in that it decreases the durability and service life of the pavement against failures such as rutting. This and other inherent problems with asphalt binders can be addressed by using modifiers that are added to bitumen in small percentages to enhance rutting and fatigue cracking resistance as well as to increase the PG grade of the asphalt binder (Somayaji, 2001). Polymer modifiers are popular means to increase the field performance and longevity of asphalt mixtures. However, the costly nature of polymer modifiers has stimulated research into cheaper, more cost-effective modifiers produced from recycled materials (Ahmadinia *et al.*, 2012).

1.2 Statement of Research Problem

Asphalt concrete mixture usually experiences stresses due to high traffic volume, truck traffic and higher tire pressures. One of most common form of distress of asphaltic concrete pavement is permanent deformation. Polyethylene terephthalate as an additive has a toughness characteristics that resist permanent deformation in asphaltic concrete pavement, hence this study.

1.3 Justification of the Study

This research is justify because recycling of used PET as a means of reducing environment pollution since the waste PET are used to as addition to the asphalt binder.