AN APPROACH TO REUSE POLYEHTYLENE TEREPHTHALATE BOTTLES AS PLSTIC COATED AGGREGATE IN ROADS AND THEIR ENGINEERING PROPERTIES

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A project report is submitted in partial fulfillment of the
requirements for the award of the degree of
Master of Engineering (*Construction Management*)

Faculty of Civil Engineering
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JANUARY 2017

DEDICATION

This project report is dedicated to my beloved father **Muhammad Israr Baig** (late), my mother **Najma Israr** and my brother **Muhammad Adeel Israr** for their endless support and encouragement.

ACKNOWLEDGMENT

I would like to express my gratefulness to all entities that are involved in my project work. In preparing this project, I was in contact with many people, researchers, academicians and technicians. They all have contributed to my understanding and valuable thoughts during my project.

First and foremost, I wish to express my sincere appreciation to my supervisor, Dr. Maniruzzaman A. Aziz for encouragement, guidance and critics. Their kindness and encouragement helped me to persevere along the way. Without their continued support and advices, this thesis would not have been the same.

Last but not least, I am grateful to all my family members for their moral and financial support and understanding all this time.

ABSTRACT

Preservation of road infrastructure requires a systematic approach for the good performance of roads keeping in mind the future condition and maintenance scenarios. Now-a-days pavements are subjected to various kinds of loading which affects the pavement performance condition that causes various distresses. These distresses include rutting, fatigue cracking, and temperature cracking. Looking forward to the environmental condition, complete ban on plastic cannot be made. Thus, using of plastic as an innovative technology not only strengthened the road construction but also increase the road life. This study includes the results of the various laboratory tests conducted on bitumen, aggregate and bitumen-aggregate plastic mix.This study investigates the rheological properties of bitumen (asphalt) binder penetration grade 60-70 modified with an additive Polyethylene Terephthalate (PET). Bitumen is visco-elastic material where temperature and rate of load application have a great influence on their performance. The properties evaluated include the rheological properties of the modified bitumen binder. These properties were penetration by Penetro meter and softening point by Ring and Ball test. The binders were mixed with various percentages of waste PET bottles 5, 10 and 15% by weight of bitumen binder.

ABSTRAK

Pemeliharaan infrastruktur jalan memerlukan pendekatan sistematik untuk prestasi jalan raya yang lebih baik dengan mengambil kira keadaan dan penyelenggaraan jalan pada masa akan datang. Pada masa kini laluan berturap adalah tertakluk kepada pelbagai jenis muatan yang memberi kesan kepada keadaan prestasi turapan yang menyebabkan berlakunya pelbagai rekahan. Rekahan jalan ini termasuk aluran, retakan, dan retakan akibat suhu. Mengambil kira keadaan alam sekitar, larangan penggunaan plastik tidak boleh dibuat. Oleh itu, dengan menggunakan plastik sebagai teknologi inovatif bukan sahaja mengukuhkan pembinaan jalan raya tetapi juga meningkatkan hayat jalan raya. Kajian ini meliputi keputusan pelbagai ujian makmal yang dilakukan terhadap bitumen, batu baur dan campuran bitumen-batu baur. Kajian ini mengkaji sifat-sifat reologi bitumen (asfalt) pengikat penembusan gred 60-70 diubahsuai dengan Terephthalate tambahan Polyethylene (PET). Bitumen adalah likat-kenyal bahan di mana suhu dan kadar permohonan beban mempunyai pengaruh yang besar terhadap prestasi mereka. Sifat-sifat dinilai termasuk sifat-sifat reologi bitumen pengikat yang diubah suai. Ciri-ciri ini telah penetrasi oleh Penetro meter dan titik lemah oleh Ring dan ujian Bola. Pengikat telah bercampur dengan pelbagai peratusan botol sisa PET 5, 10 dan 15% mengikut berat bitumen pengikat.

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LIST OF ABBREVIATIONS / SYMBOLS

AC	-	Asphaltic Concrete
ASTM	-	American Society for Testing and Materials
G_{mb}	-	Bulk specifife gravity of compacted mix
G_{sb}	-	Combined bulk specific gravity of total aggregate
HMA	-	Hot Mix Asphalt
JKR	-	Jabatan Kerja Raya
OBC	-	Optimum Bitumen Content
PET	-	Polyethylene Terephthalate
SSD	-	Saturated-surface-dry
WPB	-	Waste plastic bottles

CHAPTER 1

INTRODUCTION

1.1 Introduction

Plastics are commonly used substances which play an important role in almost every aspect of our lives. The widespread generation of plastics waste needs proper end-of-life management. The highest amount of plastics is found in containers and packaging's (i.e. bottles, packaging, cups etc.), but they also are found in durables (e.g. tires, building materials, furniture, etc.) and disposable goods (e.g., medical devices). Diversity of plastics applications is related with their specific properties, low density, easy processing, good mechanical properties, good chemical resistance, excellent thermal and electrical insulating properties and low cost (in comparison to other materials). Post-production and post-consumer plastics are utilized in a wide range of applications. However, in this field two main direction should be mentioned: 1) using of plastic waste as alternative fuel (burning) in cement kilns and power plants and 2) material recycling of waste polymers. According to the U.S. Environmental Protection Agency (USEPA 1992), the municipal solid waste (MSW) generated in the United States is 200,000,000 tons/year, among them about 38%wt being paper products, 8%wt plastic, and 3% wt. carpets and textiles. In the year of 1996, content of plastics in MEW raised to 12%wt. The worlds annual consumption of plastic materials has increased from around 204 million tons in the 2002 to nearly 300 million tons in 2013. Moreover, production and consumption of polymers and plastics will be constantly growing in next year. In Table I estimated data about types and quantities of polymers in MSW stream generated annually in United States are presented. As we can see main stream of plastic waste in MSW are

thermoplastics polymers poly(ethylene), poly(propylene), poly(styrene) and poly (ethylene terephthalate).

In India approximately 40 million tons of the municipal solid waste is generated annually, with evaluated increasing at a rate of 1.5 to 2% every year. Plastics constitute to around 12.3% wt of the total MSW. It is worth to notice, that the most of plastics fraction are drinking bottles which are made mainly of PET.

Plastic (polymers) used for applications in bitumen modifications, can be subdivided into two main types depending on their behavior after exposure to heat. First type are thermosetting polymers (e.g. resins, elastomers) which are cured during heating. Three-dimensional structure of cross-linking bonds formed during curing unable softening of polymer matrix and its easy re-processing. Second type are thermoplastic polymers. This type of polymers can be shaped and designed in new shapes using heat. In contrary to thermosetting polymers this process is reversible. The plastics used for bitumen modification may be also classified as thermoplastic and thermosets.

Asphalt has been widely used in road pavement construction as the binder of aggregates. However, it is well recognized that asphalt mixture or coating layer shows severe temperature susceptibility such as high temperature rutting, medium temperature fatigue and low temperature cracking damage (Fig. 2). Therefore, asphalt mixture modification is sometimes used to improve its further application. Improvements in asphalt properties sometimes can be achieved by either selecting the proper starting crude oil, or by controlling the refinery processes aimed at making desired asphalts, which are both unfortunately very difficult to attain. Therefore, the popular method for improvement of asphalt quality is its modification. Air blowing makes asphalt harder. Fluxing agents or diluent oils are sometimes used to soften the asphalt. Another method that can significantly improve asphalt quality is the addition of polymers. Asphalt modification with polymers is a common method for improvement of rheological properties of asphalt.

A very important property of the asphalt mixture is its ability to resist shove and rutting under long-lasting traffic and traffic loading repetitions. Therefore, asphalt stability should be suitable enough to handle traffic adequately. The lack of stability in an asphalt mixture means unraveling and flow of the road surface. Flow is the ability of hot mixture asphalt (HMA) pavement to adjust to gradual settlements and movements in the subgrade without cracking.

The viscoelastic properties of the asphalt are significantly affected by the chemical composition and hence they have a direct effect on asphalt performance. Pavements defects such as rutting at high temperatures, cracking at low temperature region and others are due not only to traffic loads but also to the capability of the asphalt concrete to sustain temperature changes. Increased traffic factors such as heavier loads, higher traffic volume, and higher tire pressure demand higher performance of road pavements. A higher performance pavement requires asphalt that is less susceptible to high temperature rutting or low temperature cracking, and has excellent bonding to stone aggregates.

The uses of virgin polymers in asphalt to improve the characteristics of the resulting polymer modified asphalt have been accomplished for many years. Nevertheless, recently there is an interest in the substitution of commercial virgin material by recycled polymers e.g. shredded waste plastic containers made of PET. Reclaimed rubber obtained from waste tires has been also used with positive effects in pavements. Substitutions technique for asphalt in pavements, including the hot mix and the cold mix by polymers such as PET, is put into practice for the improvement of rutting resistance, thermal cracking, fatigue damage, stripping, and temperature susceptibility. They are used when extra performance and durability are desired. In many cases, they are selected to reduce life cycle costs. Polymer modified binders also show improved adhesion and cohesion properties.

The high cost of polymers compared to asphalt means that the amount of polymer necessary for improved pavement performance should be as small as possible. From an environmental and economic point of view, it is possible to imagine the possibility of disposing of waste plastics such as PET bottles within road

asphalts because similarity in performance is found between recycled polymers and virgin polymers modified asphalt. Thus, the use of CR (crumb rubber) from used tires or thermoplastic polymers such as PE, PET, or EVA, as an asphalt-modifying agent may contribute to solve a waste disposal problem and to improve the quality of road pavements. Many polymers have been used as binder modifiers, and they can be classified into several groups, each with advantages and disadvantages as asphalt modifiers.

The main reasons to modify asphalts with plastics are: 1) obtaining softer blends at low service temperatures and reducing cracking, 2) obtaining stiffer blends at high temperatures and reducing rutting, 3) reducing viscosity, 4) increasing the stability and the strength of mixtures, 5) improving the abrasion resistance and fatigue resistance of blends, and oxidation and aging resistance, 6) reducing structural thickness and life costs of pavements. It is well known that polymers can successfully improve the performance of asphalt pavements at almost all temperatures by increasing mixture resistance to fatigue cracking, thermal cracking and permanent deformation.

1.2 Problem Statement of the Project

Nowadays, we depend on the road to transport us from one place to another place almost every day in our lives. The quality of road of a country determines the level of development of those country posses flexible pavements have to sustain increasingly large traffic loads. When these loads are combined with adverse environmental conditions, in some countries like Pakistan where hot climate is major problem for asphalt concrete road pavement due to bleeding and thus rutting and fatigue occurs. Due to presence of cracks some problems may occur, e.g. loss of waterproofing, loss of load spreading ability, pumping and loss of fines from the base course, loss of riding quality. Longitudinal deformation in a wheel path, rutting is irregularly occurring in the driving direction. Possible causes are settlement of the sub grade and base course, plastic deformation of bituminous materials (flow) observed longitudinally. It is accelerated by the combined effect of traffic and high

temperature and inadequate compaction in surfacing or base, therfore using of Polyethylene in bitumen modification considered as a sustainable technology which transforms an unwanted residue into a new bituminous mixture highly resistant to rutting and fatigue.

In addition, with the warm mix asphalt (WMA) technology it is expected to reduce the temperature requirements while producing the same quality of mix. WMA is a relatively new technology, and there is a need to find the effects of warm asphalt additives on the binders and the mixtures in detail. There are many adverse effect and consequences associated with the production of hot mix asphalt. These include high energy consumption to maintain workable temperatures, and hazardous asphalt fumes that are harmful to the health of the workers at the production plant and during construction. Asphalt mix producers seek environmentally friendly, energy efficient, and worker friendly methods.

1.3 Objectives

The objectives of his study are:

- To determine the engineering properties of aggregates with different percentage of waste plastic, like impact test & Loss Angel's Abrasion Test.
- To determine the properties of bitumen with different percentage of waste plastic, like softening point, penetration test, ductility test.
- To determine the marshal stability of plastic coated aggregate asphalt with different percentages of plastic.

1.4 Scope of Study

Waste PET bottles improves the quality of pavement because plastic is water repellent in nature, also decrease the consumption of bitumen and to utilize plastic waste in efficient manner. There are a few of limitation has been set up to achieve the expectation of the research:

- The percentage of fibers used in this study are 0%, 5%, 10% and 15%.
- Aggregates of 10 mm must be used.
- Bitumen grade 60/70
- Source of water must be university tap water (UTM).

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