Effects of different additives on the behavior of asphalt

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Abstract– ***Highways are very important in mobility and accessibility from and to any place. The growing traffic loads causes many problems in the asphalt pavements. Researchers focuses on the applications of different additives in the field of asphalt paving. This paper is a literature survey that discuss the modification of asphalt. Additives may be added to the asphalt binder or to the aggregates. There are many different additives used in the modification of asphalt mixtures. Many of them have significant effects on the behavior of the asphalt binders or on the asphalt mixtures. Polymer is one of the most common additives used in asphalt modification. There are two types of polymers. The two types are thermoplastic polymers, and thermosetting polymers. Both types have great effects on the asphalt binder behavior. The main goal of using additives is to reduce the maintenance of the roads, improve the quality and durability. Reducing maintenance means reducing costs.***

Keywords—Asphalt, Additives, asphalt behavior, Polymer, Nanotechnology.

I. INTRODUCTION

The goal of this study is to provide a literature survey in the field of different additives. The focus of this survey is on the applications of using these additives in the field of asphalt paving. This study integrates literature review, preparation, and characterization of modified asphalt material

On most roads, conventional asphalts perform well. However, traffic demands made upon roads increase year by year. Ever increasing numbers of commercial vehicles with super single tires and increased axle loads take their toll and this trend will continue in the future.

Egypt is one of the developing countries that have a rapidly expanding road network. Because of the great spread of road construction, there will be a great demand for construction materials. Due to the heavy traffic loads passing on the existing roads and newly constructed roads, paving defects are generated for the asphalt. There are many types of distress occurred in asphalt paving. There are many failures and damages that occurs to roads as shown in fig. (1) to fig. (4). Distresses differ according to the cause of each defect, the quality of asphalt paving materials, the quality of construction, and the appropriate use of the road in terms of the traffic loads permitted for each road. Therefore, many researchers were interested in finding appropriate solutions to fix problems in the asphalt pavements. They also took care of the production of asphalt mixtures capable of resisting asphalt pavement defects that may occur later.

Researchers have used several methods to improve and upgrade the behavior of asphalt paving, either by improving the performance of the bitumen by upgrading the performance of hot mix asphalt (HMA) or both. Researchers have used several modifiers to improve the performance of asphalt pavements, some modifiers are used to enhance bitumen performance such as polymers of various kinds, Styrene-Butadiene-Styrene (SBS), Styrene-Butadiene-Rubber (SBR), natural rubber, crumb tire rubber, fillers, and nanomaterials. Also, the properties of the used aggregate can be improved by adding or replacing coarse, fine, or powdered aggregates. Examples of those materials used to improve the properties of aggregate blends are iron slag, fractured basalt, marble dust, Metakaolin, cement, fly earth, nanomaterials, and others.

To assist the Highway Engineer to meet this growing challenge, there now exists a wide range of proprietary asphalts made of many materials one of the most common materials is polymer-modified bitumen and a range of polymer-modified bitumen for generic asphalts, all of which have been proven in service.

And second Material is Nanotechnology.

Nanotechnology is the creation of new materials, devices, and systems at the molecular level as phenomena associated with atomic and molecular interactions strongly influence macroscopic material properties [1]. Even though engineers are interested in material properties at the macro and Meso-scales, the Nano and micro scales provide fundamental insight for the development of science and technology.

micro [2], Nano, and to quantum scales. Although improvements

in asphalt performance have been achieved through polymer modification, it will be interesting to explore what nanotechnology offers in improving asphalt pavement performance.

II. PAVEMENT DISTRESSES

Fig. (5) presents some types of asphalt pavement distresses. asphalt pavement distresses appear as a result of different reasons, as traffic loads, the weather, and the bad quality of the construction materials. So, it is necessary to study the asphalt modification by various modifiers (including nanomaterials) to produce high-performance asphalt pavements.

This paper discusses the effects of bitumen modification by different additives.

Fig.(1)Permanent deformation (Rutting)

Fig.(2)Alligator Cracking

Fig.(3)Edge cracking

Fig.(4)Longitudinal cracking

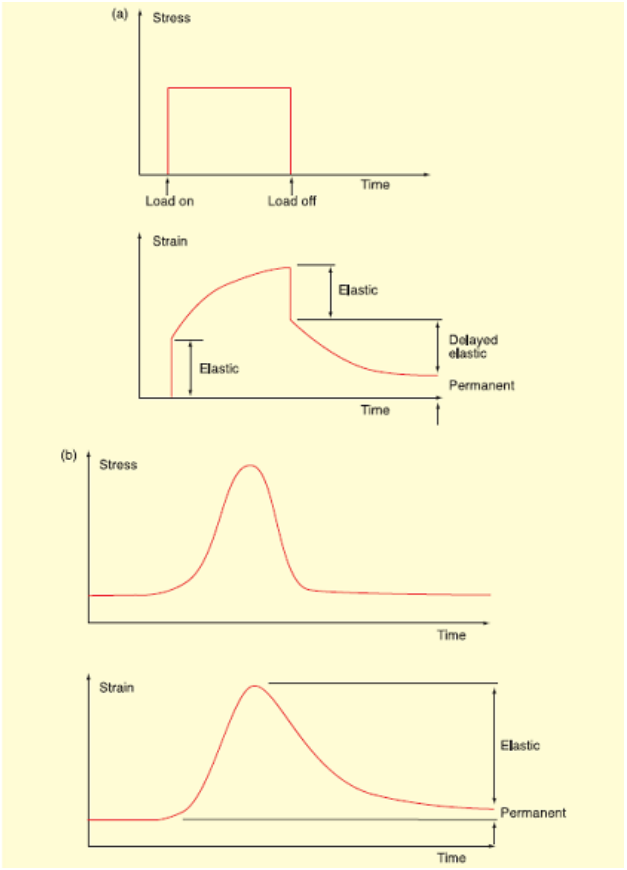

Fig. (5) Visco-elastic responses of asphalt under (a) a static load and (b) a moving wheel load

III. Literature Review

A. Polymer.

One of the prime roles of a bitumen modifier is to increase the resistance of the asphalt to permanent deformation at high road temperatures without adversely affecting the properties of the bitumen or asphalt at other temperatures. This is achieved by one of two methods, both of which result in a reduction in permanent strain. The first

approach is to stiffen the bitumen so that the total visco-elastic response of the asphalts reduced. The second option is to increase the elastic component of the bitumen thereby reducing the viscous component.

Both methods are depending on each other and are mainly used all over the world.

TYPES OF POLYMERS

Types	Appearance	
	Thermoplastic polymers	Thermosetting polymers
1	Ethylene vinyl acetate (EVA)	Epoxy resin
2	Ethylene methyl acrylate (EMA)	Polyurethane resin
3	Ethylene butyl acrylate (EBA)	Acrylic resin
4	Atactic polypropylene (APP)	Phenolic resin
5	Polyethylene (PE)	
6	Polypropylene (PP)	
7	Polyvinyl chloride (PVC)	
8	Polystyrene (PS)	

Thermoplastic polymers, when mixed with bitumen, associate below certain temperatures increasing the viscosity of the bitumen. [3]

1. The modification of bitumen by the addition of rubbers.

Polybutadiene, polyisoprene, natural rubber, butyl rubber, chloroprene, random styrene–butadiene–rubber amongst others have all been used with bitumen but their effect is mainly to increase viscosity. In other ways, the rubbers have been used in a vulcanised (cross-linked) state, e.g. reclaimed tyre crumb, but this is difficult to disperse in bitumen. Successful dispersion requires high temperatures and long digestion time sand can result in a heterogeneous binder with the rubber acting mainly as a flexible filler.

2. The modification of bitumen by the *addition of viscosity Reducers*

Several performance properties of asphalt can be improved by adding low molecular weight polyethylene or paraffin wax to bitumen. At temperatures above the melting point of the additive, the viscosity of the bitumen is significantly reduced compared with that of bitumen modified with Sulphur. This, in turn, allows for a reduction in asphalt mixing and laying temperatures by up to 308C, thereby saving energy and reducing fume emissions. Also, critical applications where

hand laying may be required or laying material at low ambient temperatures may be facilitated as a result of the longer time period available between asphalt mixing and compaction.

At the crystallisation temperature of the additive, the viscosity of the modified bitumen rises sharply which in turn may lead to enhanced asphalt stiffness thereby reducing the permanent deformation of the carriageway. However, the low-temperature properties may be adversely affected. Figure (6) shows typical viscosity/stiffness–temperature relationship of a penetration grade bitumen modified with a selected paraffin wax.

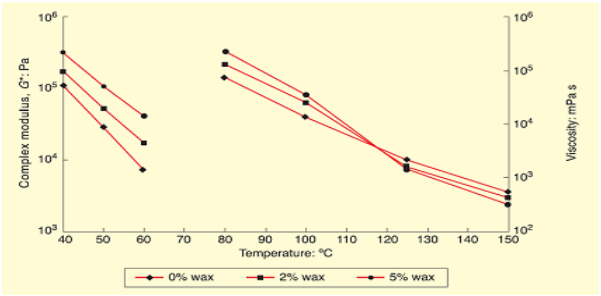

Fig. (6) The effect on the viscosity of a bitumen of adding a selected paraffin wax.

3. The modification of bitumen by the addition of Sulphur.

Sulphur is used to modify both bitumen and asphalt. In relatively low concentrations, 2 to 3%, it reduces the high-temperature viscosity of bitumen improving the workability of asphalt when hot and the deformation resistance when cold [4]. It is also used in some polymer modified bitumen to cross-link the bitumen and the polymer to improve storage stability. At higher concentrations, the sulphur substantially reduces the viscosity of asphalt making it virtually self-compacting. This makes it possible to lay this material through a paver without the need for roller compaction. Alternatively, it can be made sufficiently free-flowing that it can be used for filling potholes and levelling by hand with a trowel. As the material cools, the excess sulphur partially fills and conforms to the shape of the voids in the compacted material keying together the aggregate particles. When this material is cold, the resulting friction between particles within the asphalt makes it very resistant to deformation and very durable. The major weakness of this material is that above 1508Chydrogen sulphide is emitted and this requires the use of specialist equipment [4].

B. Nanotechnology.

Nanotechnology is one of the modern branches of science that is currently widely used in many fields. Nanomaterials are one of the applications of using nanotechnology in areas related to the study of improving and modifying the properties of materials and their various uses, for example in asphalt paving, concrete, and others.

Nanotechnology has many applications in every branch of science. Nanotechnology is the control of materials and gadgets by controlling the matter at the atomic level (nanometer scale). Nanotechnology also includes utilizing the properties and measurement in materials, and apparatuses by controlling the material at the atomic level (nanometer scale) [5].

Richard Feynman is considered one of the godfathers of nanotechnology. On December 29, 1959, he gave his point of interest at a presentation presented to the American Physical

Society at Caltech, his title line was, “There’s Plenty of Room at the Bottom.” At that time, Feynman amplified a welcome for “manipulating and controlling things on a little scale, subsequently entering an unused field of material science which was bottomless, like low-temperature physics.”[6]. He wanted to discuss the problem of controlling and manipulating things on a small scale.

engineers are interested in material properties at the macro and Meso scales, the nano and micro scales provide fundamental insight for the development of science and technology. Fig. (7) illustrates the evolution of length

scales of an asphalt concrete material (in macro scale), to Me so, micro [7], Nano, and to quantum scales.

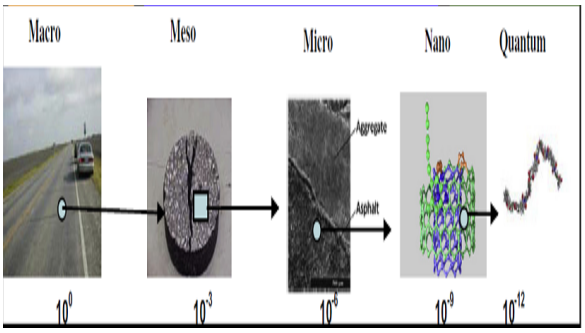

Fig. (7) Illustration of the evolution of different asphalt dimensions.

In China, Yu has studied the effect of a Nano clay (montmorillonite)on properties of styrene–butadiene–styrene (SBS) copolymer modified asphalt [8] by melt blending with different contents of sodium montmorillonite (Na-MMT) and organophilic montmorillonite(OMMT). It was found that the addition of Na-MMT and OMMT increases the viscosity of SBS-modified asphalt. In addition, the Nano clay/SBS-modified asphalt gained a higher complex module sand lower phase angle, implying stiffer and more elastic asphalt. Therefore, the Nano clay-modified asphalt was determined to have good rutting resistance compared to the original asphaltor the SBS-modified asphalt. It was found that MMT-modified asphalt may form an intercalated structure, whereas the OMMT modified asphalt may form an exfoliated structure based on the X-ray diffraction (XRD) results [9,10].
Research conducted in the Netherlands suggests Nano clay modifications improve some characteristics of asphalt binders and asphalt mixtures, but more research is required before it can be applied on a large scale [11].

IV. Conclusion

Based on the previous studies, it has been shown the noticeable effect of various additives. Nanomaterials are one of the promising materials which have many applications in various fields. Many types of nanomaterials have been used as asphalt modifiers. They were used to enhance the properties of asphalt pavements. HMA mixtures are one of the most widely used mixtures in the field of asphalt paving. Nano-Silica and Nano-Clay are among the most important materials used as additives and modifiers for HMA.

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