Improving Durability of Asphalt Mixture by Performing Partial Replacement of Bitumen with Waste Motor Oil and Elastomer Modifiers

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***Abstract*- The increasing environmental concern about waste materials and reuse of waste materials can present benefits at an environmental and economic level, and some wastes can be used to improve the pavement performance. Thus, the different waste materials in bitumen, namely waste motor oil and different polymers for 10% of waste motor oil and 5% of polymers (high density polyethylene, crumb rubber and styrene-butadiene-styrene) were added to a conventional bitumen and the resulting modified bitumens were characterized Such improvements might indicate a good behaviour at medium or high temperatures and an increase of fatigue and rutting resistance.**

***Index terms*- Conventional bitumen, high density polyethylene, crumb rubber and styrene butadiene styrene**

I.INTRODUCTION

1.1 GENERAL

The main problems of asphalt mixtures are rutting and cracking mainly due to the thermal susceptibility and ageing of conventional bitumen. Besides these problems, the increasing traffic volume and loads applied in road pavements could compromise the durability and performance of asphalt mixtures. Such factors demonstrate the need of developing binders with improved. The mostly used modifiers or additives in road paving industry are polymers. The polymers decrease the thermal susceptibility and permanent deformation, and increase the resistance to cracking of asphalt mixtures. The polymer modified bitumens typically have higher elastic response, cohesion, ductility, softening point temperature and viscosity than conventional ones .Although polymers are used in small amounts in modified bitumen (the typical percentage is 5% to 6%), the utilization of virgin polymers in bitumen modification has a high cost. Consequently, it is crucial to find an alternative for these virgin polymers, namely by using waste polymers. In fact, the characteristics of bitumen modified

Fig1.2 Waste motor oil

Fig1.3Crumb rubber

Fig1.2 SBS

Fig1.4Nanoclay

1.2 PROPERTIES OF WASTE MOTOR OIL

The main requirements for an engine oil are defined temperature viscosity properties, protection against wear and corrosion, keeping the engine clean, abrasives in suspension, yield strength under compression and many more.

1.3. PROPERTIES OF STYRENE BUTADIENE STYRENE

SBR is a highly random copolymer of butadiene and 10 to 25 percent styrene. The addition of styrene lowers the price and contributes.

1.4. PROPERTIES OF CRUMB RUBBER

The following are the physical properties of rubber for Specific gravity, Abrasion resistance, Tear

resistance, Compression set, Resilience, Elongation, Tensile modulus, Tensile strength.

1.5. PROPERTIES OF HIGH DENSITY POLYETHYLENE

It has the following properties: Stiffness, strength, toughness, resistance to chemicals and moisture, permeability to gas, ease of processing, and ease of forming.

II. BITUMEN

2.1 DEFINITION OF BITUMEN

Asphalt, or bitumen, is a sticky, black and highly viscous liquid or semi-solid, composed almost entirely of petroleum. It is present in most crude petroleum and in some natural deposits. It is the material which made the La Brea tar pits. Asphalt which is liquid is often called tar. Tar is also used for plant resin.

2.2CHEMICAL COMPOSITION OF BITUMEN

Molecular weight wise, bitumen is a mixture of about 300 - 2000 chemical components, with an average of around 500 - 700. Elementally, it is around 95% carbon and hydrogen (± 87% carbon and ± 8% hydrogen), and up to 5% sulfur, 1% nitrogen, 1% oxygen and 2000ppm metals. Bitumens are composed mainly of highly condensed polycyclic aromatic hydrocarbons. They also contain several elements, a number of which are toxic

There are a lot of techniques such as solvent Fractionation, thermal diffusion, sulphuric acid precipitation, adsorption and elution or by a combination of these procedures used for determining the composition of bitumen. The study of these fractions has been made by most available methods including infrared and ultraviolet spectrometry, x-ray analysis and electron-microscope techniques. Bitumen is a mixture of hydrocarbons and compounds of a predominantly hydrocarbon character, varying both chemically and molecular size. These hydrocarbon components change from the nonpolar aliphatic wax compounds to highly polar condensed aromatics. Carbon and hydrogen compose approximately 90-95% of bitumen. The rest of the bitumen consists of heteroatoms such as nitrogen, oxygen and sulphur.

2.3 USES OF BITUMEN

Bitumen is used in road construction due to various properties and advantages it has over other pavement construction materials. Bitumen gain certain unique properties that are inbuilt in it during its manufacture. The bitumen as a raw material in flexible road construction and bitumen as a mix (composing other materials i.e. aggregates/ pozzolans) serves certain advantages, that prompt to use bitumen widely in road construction

III. MODIFICATION OF BITUMEN

3.1 Modification Methods

The production of the modified bitumen was carried out in two phases:

- Firstly, by adding waste motor oil and different polymers (high density polyethylene, styrene-butadiene-styrene and crumb rubber) to the conventional bitumen, using a low shear mixer, in order to obtain an initial blend at a temperature of 180°C
- Then, those initial blends were placed in a high shear mixer at 7200 rpm, at 180°C, for additional 20 min.

The bitumen was modified with a percentage of 5% of each of the three different polymers, since that is the typical percentage of polymer used in the paving industry. The waste motor oil was applied in an amount of 10% taking into account that the maximum percentages already used in recycling mixtures were less than 7%. The amount of this waste was slightly increased in order to obtain a more sustainable solution without severely reducing the rut resistance of the new binder. It should be noted that one of the samples was modified only with waste motor oil for comparison reasons.

- Conventional bitumen
- Commercial modified bitumen
- B + 10% Motor oil + 5% SBS – PHASE I
- B + 10% Motor oil + 5% Crumb rubber – PHASE II
- B + 10% Motor oil + 5% HDPE – PHASE III

3.2 Purpose of Modification

Nowadays a lot of different materials are being sold in the market in the name of bituminous additives or modifiers.

- Increased fatigue resistance

Due to the addition of the modifier polymer to the bitumen, the bitumens elasticity get increased and hence there will be decrease in the permanent deformation due to wheel load.

Property or Characteristic	Unit	Requirement or Value
Acidity	%	0.56
Moisture	-	0.25
Viscosity at 37c	mm^2/s	44.78
Iodine index	cgl2/g	108.22
Un saponifiable materials	%	1.70
Saponification index	mg/g	195.87
Ash	-	0.030
Refractive index at 25c	kg/m^2	1.4700
Density	-	910

- Stability increases

The addition of polymer to the bitumen increases the elastic nature of the bitumen. Hence they provide very high resistance to permanent deformation.

- Temperature susceptibility increases

The modification of bitumen using polymer improves the temperature susceptibility of bitumen by increasing binder stiffness at high service temperature and reducing stiffness at low service temperatures.

- Decrease in total cost of pavement

The usage of modifiers may cause an increase in initial construction costs, but in time it should decrease the overall costs of the pavement by significantly lowering the maintenance.

- Modified bitumen

It can be better adhesion between aggregates and binder lower susceptibility to temperature, variations higher fatigue life of mixes. Higher resistance to deformation at high pavement and temperature delay of cracking and reflective cracking overall improved performance.

IV. ADDITIVES WITH BITUMEN

4.1 GENERAL

The new asphalt binder and mixture evaluated in this work showed that the blend of bitumen, waste motor oil and SBS has better properties than those of conventional bitumen and results in an asphalt mixture with improved performance in comparison to the conventional asphalt mixture. Actually, the asphalt mixtures with the new modified binders, namely with waste motor oil and (high density polyethylene, crumb rubber and styrene-butadiene-styrene) showed very good performance in all tests carried out during this study.

4.2 PHYSICAL PROPERTIES AND MATERIAL SPECIFICATION OF STYRENE BUTADIENE STYRENE

Table 4.2 Physical properties of SBS

Property or Characteristic	Unit	Requirement or Value
Appearance	-	off black liquid
total solid content	%	$62.0 \pm 1.0\%$
specific gravity	-	0.95
ph value	-	5.0 ± 0.5
Viscosity	cps	1000 ± 500
boiling point	-	100c (water)
recommended dosage	-	3% (up to 25%)
Density	g/cm3	0.909

4.3 PHYSICAL PROPERTIES AND MATERIAL SPECIFICATION OF CRUMB RUBBER

Table 4.3Physical properties of crumb rubber

Property or Characteristic	Unit	Requirement or Value
Gradation (maximum size)	mm	0.4
Specific gravity	g/cm3	1.11 to 1.15.
Acetone extract	%	19+2
Ash	%	15
Rubber hydrocarbon	%	48+2
Viscosity	-	35 to 45
Tensile strength	kg/cm2	50+5
Carbon black	%	18

4.4. PHYSICAL PROPERTIES AND MATERIAL SPECIFICATION OF HIGH DENSITY POLYETHYLENE

Table 4.4 Physical properties of high density polyethylene

Property or Characteristic	Unit	Requirement or Value
Density	kg/m^3	940
Melting Point	°C	130.8
Temperature of crystallization	°C	111.9
Latent heat of fusion	kJ/kg	178.6
Thermal conductivity	W/m.°C	0.44
Specific Heat Capacity	J/kg-K	1330 to 2400

V. CONCLUSION

The new asphalt binder and mixture evaluated in this project shows that the blend of bitumen, waste motor oil and SBS has better properties than those of existing bitumen and results in an asphalt mixture with improved performance in comparison to the conventional asphalt mixture. Actually, the asphalt mixtures with the new modified binders, namely with waste motor oil and SBS and with bio-oil and ground rubber, showed very good performance in all tests carried out during this study.

In particular, the asphalt mixture with waste motor oil and SBS showed a higher fatigue cracking resistance, higher stiffness and rutting resistance, but both mixtures generally performed well during the laboratorial study. It also becomes clear that the new mixture with waste motor oil and SBS performs better than the conventional mixture. The very good performance of the new binders and mixtures with waste-derived oils and elastomer modifiers made the potential of these economical and environmentally friendly solutions and also a durable in nature which is used real road paving.

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