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The Effects of Styrene-Butadiene (SBR), Polyethylene Bag (PEB) on the Properties of Bitumen

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ABSTRACT

This study investigates the use of Styrene-butadiene (SBR) and Polyethylene Bags (PEB) as modifiers on properties of bitumen. Bitumen modifier (SBR, PEB and SBR/PEB) at 0, 3, 6, 9, 12 and 15% by weight of 500g hot bitumen were used. The bitumen and percentages of SBR, PEB, and SBR/PEB were heated until the PEB, SBR, and SBR/PEB added was melted, thereby stirred thoroughly with each other in each container of the specimen. The modified bitumen (i.e. bitumen with the additives at 3, 6, 9, 12 and 15%) and unmodified bitumen (control bitumen) were allowed to cool to a temperature of 85^{o}C. The modified and unmodified bitumen were subjected to penetration, ductility, softening point of bitumen, and flash and fire point of bitumen tests.

The results obtained in each test shows that using SBR/PEB as modifier on the properties of bitumen would not only increase the lifespan of the road pavement but also serves as the means of managing the waste menace.Utilization of these waste (SBR and PEB) in bitumen proved that it would enhance the properties of the bituminous mix in addition to solve disposal problem.

Keywords: Bitumen, Styrene-butadiene, polyethylene bag, physical properties

1.0 INTRODUCTION

Polymeric additives have been widely used to improve the properties of bitumen in service life. The addition of polymers to bitumen changes the rheological properties of bitumen and it is expected to improve bitumen properties at low and high temperatures in service. Consequently, bitumen should be strong enough to withstand traffic loads at high temperatures, which may cause permanent deformation, rutting, and should be flexible enough to avoid excessive thermal stresses at low pavement temperatures (Vesna *et al.*, 2013). Hence, this study investigated the use of polymers(a large molecule, or macromolecule, composed of many repeated subunits) namely, Polyethylene Bag (PEB) and Styrene-Butadiene-Rubber (SBR) on the properties of bitumen. The terms polymer are often synonymous with plastic (Nuha *et al.*, 2015).

Polyethylene Bags (PEB) is the most popular type of plastic. Millions of metric tons of PEB are produced every year worldwide to be used mainly in packaging. Polyethylene is durable and degrades very slowly as other plastics. The process of biodegrading of plastics is very slow; and therefore, it remains for a long time in the environment causing pollution and threat to wildlife. Also, significant amount of plastics are not disposed properly but rather they are left in the environment. Green industry and recycling waste materials is a global trend nowadays. Therefore, it will be very effective to convert PEB used in daily life from a pollutant to a useful material such as bitumen and asphalt modifier (Mutiu *et al.*, 2013).

Styrene-butadiene or styrene-butadiene rubber (SBR) describe families of synthetic rubbers derived from styrene and butadiene (the version developed by Goodyear is called Neolite (Steven, 2004). About 50% of car tires are made from various types of SBR. The styrene/butadiene ratio influences the properties of the polymer: with high styrene content, the rubbers are harder and less rubbery. SBR is not to be confused with a thermoplastic elastomeric made from the same monomers, styrene-butadiene block copolymer (Werner *et al.*, 2012).

Hinislioglu and Agar (2004) observed the improved adhesion and cohesion property in consequence of the applying polymer modified binders. High density polyethylene (HDPE) can also be used as a modifier of asphalt concrete and this modified binder become more resistant to permanent deformation and it contributes to recirculation of plastic wastes as well as the solid waste disposal problem is relatively solved.

Sabina *et al.*, (2009) embarked on a comparative performance which was investigated using 8% and 15% waste plastic/polymer by wt. of bitumen with conventional bituminous concrete mixes prepared with 60/70 penetration grade bitumen. They describe the performance of bitumen with the inclusion of plastic/polymer which were 8% and 15% by weight of bitumen. Their experimental results indicate that at 8% plastic/polymer by weight of bitumen gives the better result than 15% plastic/polymer.

Several investigations have found that the strength of the paving mixes can be enhanced by the use of a binder formed by modifying available bitumen with certain additives like Sulphur and organic polymer. The modified polymers also improve temperature susceptibility and viscosity characteristics. Modified bitumen containing 10% waste polyethylene can be used in the road construction particularly in the warmer region (Rahman *et al.*, 2012). Low-density polyethylene carry bags collected from domestic solid waste can be used as the modification of 80/100 paving grade bitumen (Punith and Veeraragavan, 2010). Bitumen can be mixed with waste polyethylene terephthalate which acts as an additive (Kalantar *et al.*, 2010).

2.0 MATERIAL AND METHOD

2.1Materials

The materials used in this study are bitumen, PEB and SBR (crumb rubber). The bitumen was grade 60/70 which was collected from Espro Ashalt Company, Wasinmi (along Ibadan-Ikire Expressway), Nigeria. PEB (pure water sachet as shown in Figure 1) was sourced within the locality, shredded into pieces of size 50 by 5mm, washed and cleaned by putting them in hot water for 3-4 hours, dried and burnt before it was added with bitumen. The SBR was also sourced locally (i.e. used tyre) and grinded into powdered form (as shown in Figure 2) before added to the bitumen.

Figure 1: Polyethylene Bag (Pure water sachet)

Figure 2: Processed Styrene-butadiene (Crumb rubber)

2.2 Methods

This study investigated the use of SBR, PEB and SBR/PEB on the properties of bitumen. Bitumen modifier (SBR, PEB and SBR/PEB) at 0, 3, 6, 9, 12 and 15% by weight of 500g hot bitumen wereused. The bitumen and percentages of SBR, PEB, and SBR/PEB were heated until the PEB, SBR, and SBR/PEB added were melted, thereby stirred thoroughly with each other in each container of the specimen. The modified bitumen (i.e. bitumen with the additives at 3, 6, 9, 12 and 15%) and unmodified bitumen (control bitumen) were allowed to cool to a temperature of 85^{o}C. The modified and unmodified bitumen were subjected to penetration, ductility, softening point of bitumen, and flash and fire point of bitumen tests at Transportation Laboratory, Civil Engineering Department, The Federal Polytechnic Offa, Offa, Nigeria.

3.0 RESULTS AND DISCUSSION

3.1Penetration of SBR, PEB, and SBR/PEB

The penetration test results of the modified and unmodified bitumen obtained are presented in Figure 3.

It was observed that the SBR/PEB bitumen modification has the lowest penetration value (19 at 15%) due to the mixture of bitumen with the two admixtures (combination of SBR and PEB) compared to other modifications of bitumen that is, the SBR and PEB at 15% of values 28 and 22 respectively as presented in Figure 3.The decrease in value obtained from the SBR, PEB, and SBR/PEB modified bitumen of the penetration test make the bitumen binder harder and stronger than

unmodified bitumen binder which tends to increase the lifespan of a road pavement due to improved routine resistance of the mix

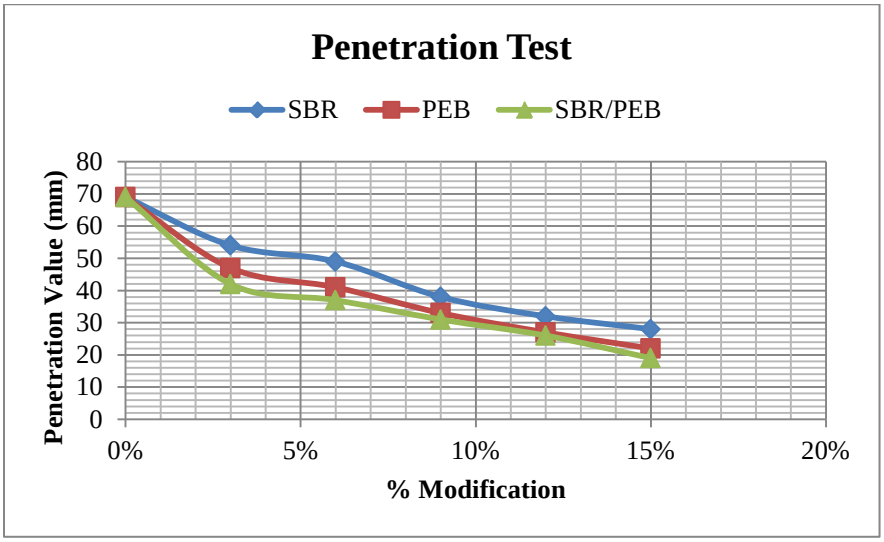

Figure 3: Penetration test on bitumen modifications

3.2 Softening point of SBR, PEB, and SBR/PEB

The softening point results of the modified and unmodified bitumen obtained are presented in Figure 4.

The results shows that modifications of bitumen with SBR/PEB have higher resistance in bitumen than other modified bitumen (i.e. SBR, and PEB). SBR/PEB modified bitumen tend to reduce the tendency of softening in hot weather and thus making the bitumen less susceptible to temperature change thereby reduced the rate of routine as the temperature increased.SBR, PEB, and SBR/PEB modified bitumen is less susceptible to temperature changes, thereby reduced the rate of routine as the temperature of softening point obtained decreased from 0 to 15 of SBR, PEB, and SBR/PEB due to the fact that SBR, PEB, and SBR/PEB have higher resistance to the effect of heat intensity.

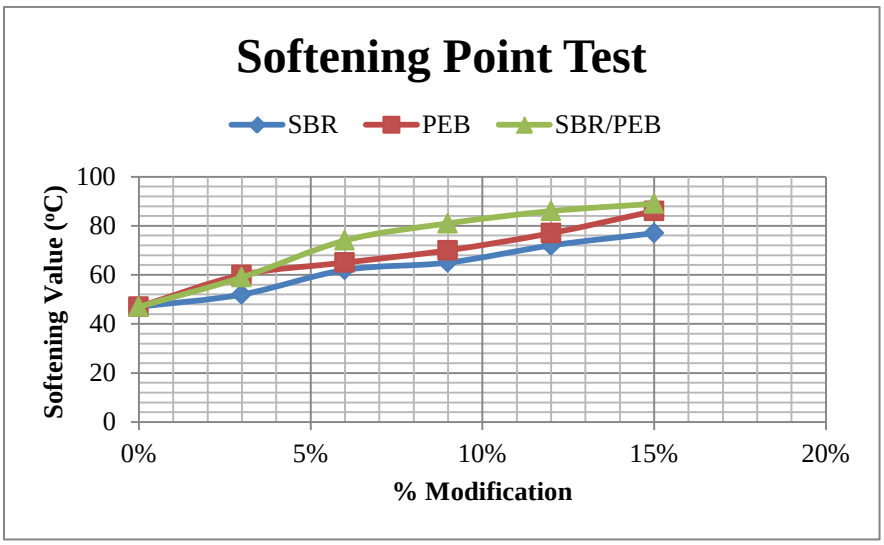

Figure4: Softening Point test on bitumen modifications

3.3 Ductility of SBR, PEB, and SBR/PEB

The ductility test results of the modified and unmodified bitumen obtained are presented in Figure 5.

The results indicated that the addition of higher percentage of SBR, PEB, and SBR/PEB to bitumen specimen will provide more strength to the road pavement so as to withstand the traffic axial load of stresses by guiding against cracking due to temperature susceptible (i.e. bituminous road pavement expands at day time and contracts at night).

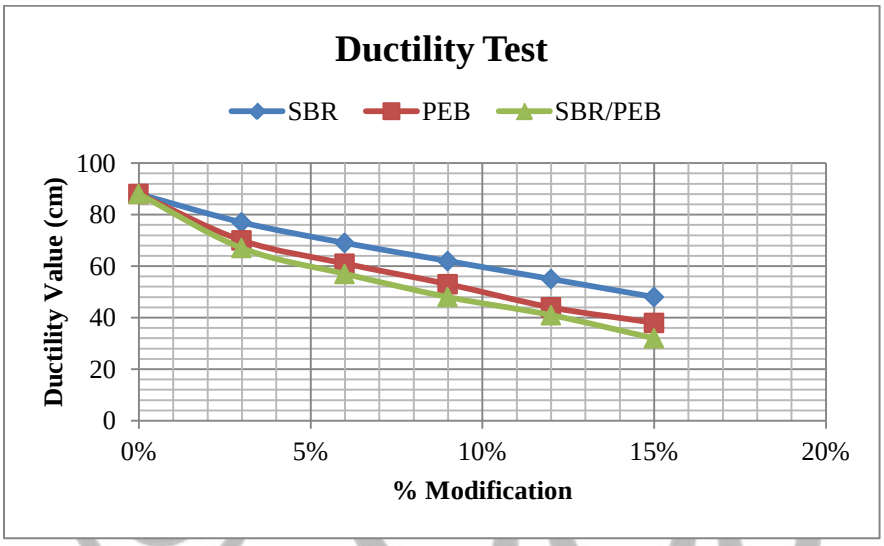

Figure 5: Ductility Test on bitumen modifications

3.4 Flash and FirePoint of SBR, PEB, and SBR/PEB

The flash and fire point test results of the modified and unmodified bitumen obtained are presented in Figures 6 and 7.

Based on the variation of temperature value obtained as presented in Figures 6 and 7, it was observed that modified bitumen with SBR, PEB, and SBR/PEB increased the temperature at which the impurity present in the bitumen is susceptible to fire and ignite to burn thus making the modified bitumen safer than unmodified bitumen.

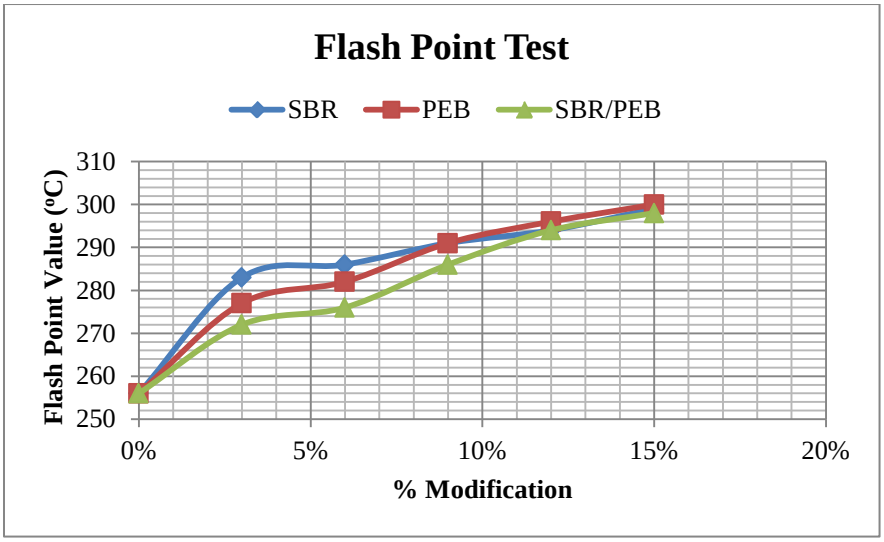

Figure 6: Flash Point Test on bitumen modifications

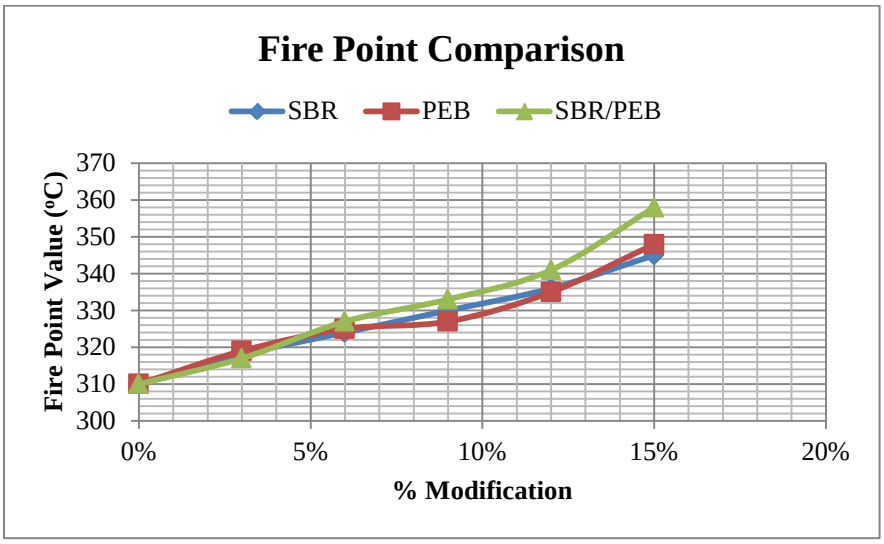

Figure 7: Fire Point test on bitumen modifications

4.0 CONCLUSION

The following conclusions can be drawn from the study:

i. The decrease value obtained from the SBR, PEB, and SBR/PEB modified bitumen of the penetration test make the bitumen binder harder and stronger than unmodified bitumen binder which tends to increase the lifespan of a road pavement due to improved routine resistance of the mix.

ii. SBR, PEB, and SBR/PEB modified bitumen is less susceptible to temperature changes, thereby reduced the rate of routine as the temperature of softening point obtained decreased from 0 to 15 of SBR, PEB, and SBR/PEB due to the fact that SBR, PEB, and SBR/PEB have higher resistance to the effect of heat intensity.

iii. The values obtained from flash and fire point tests show that SBR, PEB, and SBR/PEB modified bitumen increased the temperature at which the impurities present in the bitumen

can caught fire and ignite to burn due to the higher fire resistance of the modified bitumen achieved than the unmodified bitumen.

iv. Integration of SBR, PEB, and SBR/PEB as bitumen modifier creates positive impact on the properties determined in this study as well as solving the problem associating with the disposal of waste PEB, and SBR within the environment worldwide.

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