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Study on Application of Waste Polyethylene and SBS in Modified Asphalt

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Abstract. In this paper, modified asphalt was prepared by using waste polyethylene and SBS. Through the performance test of modified asphalt, it was found that waste PE (Polyethylene) and SBS (Styrene-Butadiene-Styrene) modified asphalt had good physical and mechanical properties. Through the asphalt mixture's test, it was found that the waste polyethylene and SBS modified asphalt mixture had good high temperature stability, low temperature crack resistance and excellent fatigue performance.

1. Introduction

Due to the development of the plastics industry and the large amount of waste plastics, plastic (represented by polyethylene PE) modified asphalt has become a newcomer in today's modified asphalt technology, and has developed rapidly at home and abroad, such as linear low density polyethylene used in the United States. Modified asphalts give them high tensile strength, cold resistance and creep resistance. In Europe, polyethylene PE modified asphalt has been patented, and several high-grade pavements had been laid in some European countries, and the modified asphalt engineering had been contracted out [1]. Japan used waste polyethylene trim to modify asphalt, which greatly improves the flexibility and durability of asphalt at low temperatures, so that the pavement would not appear obvious cracks, fractures, pits and easy laying in winter due to severe cold [2]. With the introduction of Austrian NOVOPHALT modified asphalt technology, domestic small-scale research and application of PE modified asphalt were reported[3]. In recent years, research on the preparation of high modulus asphalt with additives such as PE had gradually warmed up, and many countries had paved the test section of high modulus asphalt mixture and conducted long-term observation [4,5]. The modification of the matrix asphalt by the simple use of PE material could be excellent in its high temperature performance, but the low temperature crack resistance was not good [6,7]. Based on the low-carbon environmental protection concept, the comprehensive utilization of waste polyethylene materials was increased. This paper prepared high-performance modified asphalt by using the modification of waste PE and SBS, and the various high-performance modified asphalt mixtures were studied. The performance had been studied to lay a solid foundation for the widespread



use of waste polyethylene materials.

2. Raw materials

AH-70 paving asphalt was obtained from Zhonghai Co. Ltd in Shandong province, China, with penetration of 78.8mm at 25°C, ductility of 190cm at 15°C, softening point of 45.8°C, and viscosity of 0.48 Pa.s at 135°C according to *Standard Test Methods of Bitumen and Bituminous Mixtures for Highway Engineering (JTG E20-2011)*. The physical and chemical properties has intense effect on asphalt mixtures because of the effect of aggregate properties on the adhesive bond between asphalt and aggregate: size and shape of aggregate, pore volume and size, surface area, chemical constituents at the surface, acidity and alkalinity, adsorption size surface density, and surface charge or polarity. The mineral aggregate used in the study is limestone, the CaO, SiO₂ content is 47.6%, 24.1% respectively and is alkali according to the classification method. The crushed and weared stone value are 13.2% and 20.5% respectively. The boiling test result is up to 4 grades. The mineral filler was milled with limestone with the CaO content of 54%. Waste polyethylene was obtained from the mulch film containing low density polyethylene. SBS (Styrene-Butadiene-Styrene) with Linear structure was obtained from Kraton Co. Ltd in China.

3. Preparation process

Asphalt was heated to 170±5°C in an oil-bath heating container until it flowed fully. The appropriate amounts of waste polyethylene and SBS presented in weight percentage of asphalt were mixed into a shear blender containing the preheated asphalt. Then the blender's blade is inserted into the asphalt binder sample and operated under high rotate speed with 1500-2000r/min about 30 minutes to ensure the well dispersion of waste polyethylene and SBS in asphalt binders, and than cooling in the absence of quiver at room temperature.

4. Experiment methods

The properties of polyethylene and SBS modified asphalt, including softening point, penetration and ductility, were tested in accordance with the *Standard Test Methods of Bitumen and Bituminous Mixtures for Highway Engineering (JTG E20-2011)*. The dynamic shear rheometer was employed to measure the high temperature stability of polyethylene and SBS modified asphalt. The rutting test was used to evaluate the stability at high temperature, trabecular bending test was used to evaluate the anti-crack ability, and four point bending test was used to evaluate the fatigue ability of polyethylene and SBS modified asphalt mixtures.

5. Results and discussion

5.1. The properties of polyethylene and SBS modified asphalt

Figure 1 shows the properties of polyethylene and SBS modified asphalt. With the amount of waste PE increasing, the softing point is increased, penetration and ductility is decreased sharply, and $G^*/\sin\delta$ is increased, especially $G^*/\sin\delta$ at 60°C. The prepared asphalt meets the standard proposed standard to be high modulus asphalt [7].

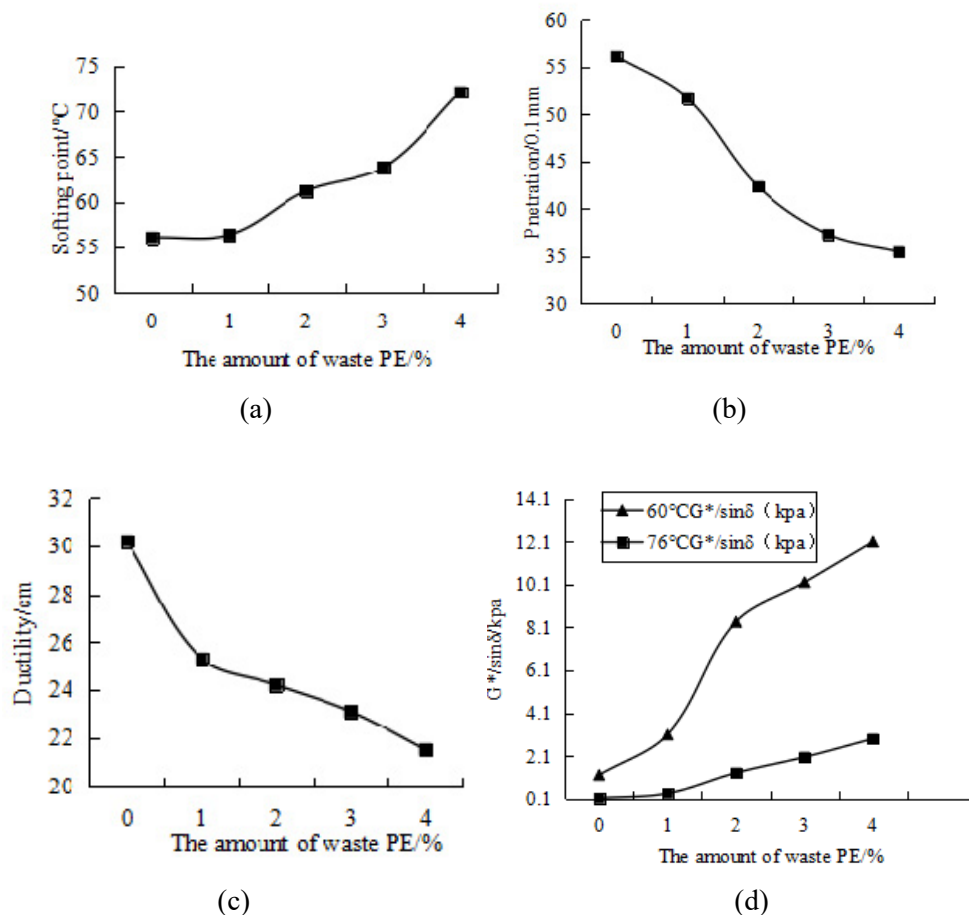


Figure 1. The properties of polyethylene and SBS modified asphalt, (a)softing point and the amount of waste PE.(b)penetration and the amount of waste PE.(c)ductility and the amount of waste PE.(d) $G^*/\sin\delta$ and the amount of waste PE.

5.2. The stability of mixtures at high temperature prepared by polyethylene and SBS modified asphalt

The rutting test was used to investigate the high-temperature road performance of each asphalt mixture (carried out at 60°C), and the test results are shown in the Figure 2. It can be seen that the maximum deformation of the matrix asphalt mixture at 60°C is 3.341 mm, the SBS asphalt mixture is 1.747 mm, and the waste PE and SBS asphalt mixture is 1.057 mm and has excellent stability at high temperature.

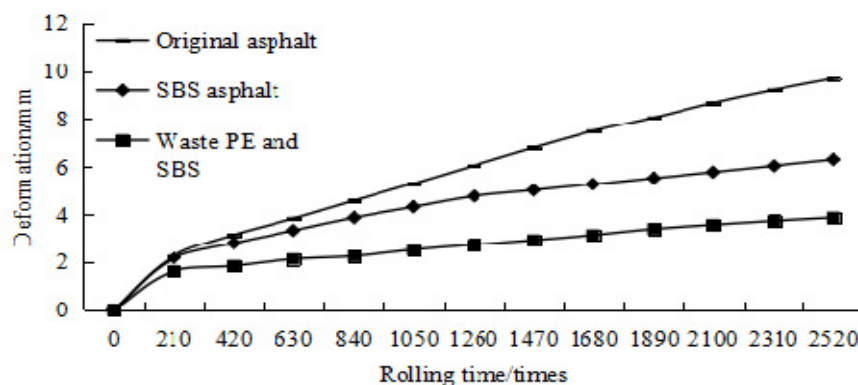


Figure 2. Relation of between deformation and rolling time

5.3. The low temperature (anti-crack ability) of mixtures at high temperature prepared by polyethylene and SBS modified asphalt

From Figure 3, original asphalt mixture has a minimum maximum bending strain (approximately up to $1816\mu\text{m}$). Waste PE and SBS asphalt mixture has biggest maximum bending strain (approximately up to $3000\mu\text{m}$), and has the best anti-crack ability.

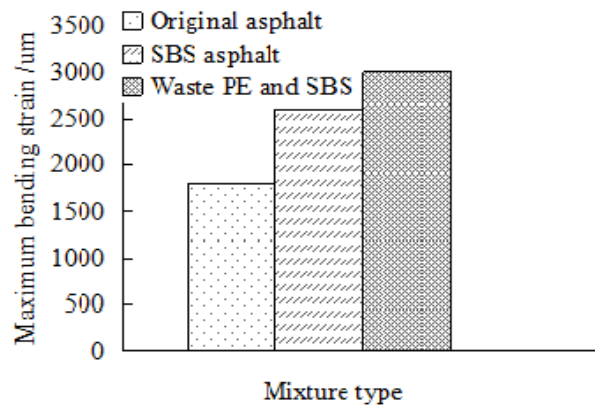


Figure 3. Maximum bending strain of each mixture type

The four-point bending beam fatigue test was used to evaluate the fatigue characteristics of the asphalt mixture. The controlled strain mode was selected (strain $300\mu\text{m}$, $400\mu\text{m}$ and $500\mu\text{m}$ test temperature 15°C , loading frequency 10Hz). The test results are plotted as shown in Figure 4. It can be seen from the Figure that the waste polyethylene and SBS modified asphalt mixture exhibits good strain fatigue resistance, the fatigue performance of the SBS asphalt mixture is in the middle, and the fatigue performance of the matrix asphalt mixture is the worst.

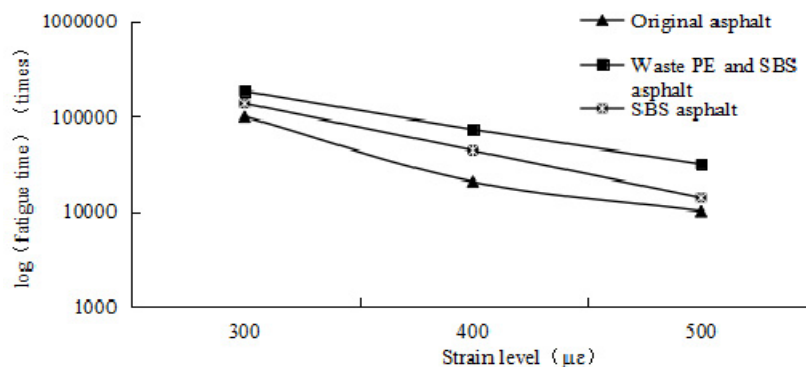


Figure 4. Fatigue characteristics of the asphalt mixtures.

6. Conclusions

1) Modified asphalt was prepared by using waste polyethylene and SBS. Through the performance test of modified asphalt, it was found that waste polyethylene and SBS asphalt had good physical and mechanical properties;

2) Through the asphalt mixture test, it was found that the waste polyethylene and SBS asphalt mixture had good high temperature stability, low temperature crack resistance and excellent fatigue performance;

3) This paper provided a good reference for the use of waste polyolefin materials.

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