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Effects of Sasobit and Its Adding Process on the Performance of Rubber Asphalt

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In order to study the effects of Sasobit on rubber asphalt, performance tests of rubber asphalt before and after Sasobit adding and tests of different Sasobit adding processes were operated. The influences of Sasobit on the performance of rubber asphalt, effects of Sasobit adding process on Sasobit rubber asphalt were acquired. The results showed that: Sasobit makes the high temperature viscosity and low temperature ductility of rubber asphalt decrease, and the softening point increase, which are favourable to the workability and high temperature stability, and disadvantageous to the low temperature ductility of rubber asphalt; the preparation process of Sasobit rubber asphalt by adding Sasobit into the finished rubber asphalt is better.

1. Introduction

The practice that waste tire rubber powder is made into rubber asphalt and applied to the asphalt pavement, can improve high and low temperature performances of asphalt pavement, and has functions of noise reduction, improving road safety and comfort features at the same time (Zhou et al., 2014). The performance of rubber asphalt is excellent, but its high viscosity and poor workability bring to the construction process of no small difficulty. In addition, the high temperature in rubber asphalt pavement construction not only increases fuel consumption, but also brings great harm to the environment. Fuel consumption and environmental pollution are problems that should be concerned about (Arapatsakos, 2011a and 2011b). Fortunately, some scholars have already paid attention to the environmental pollution in asphalt mixture production (Cornejo-Rojas et al., 2005; Ruiz et al., 2014 and 2015).

Sasobit as a warm mix agent or modifier is often applied in the asphalt pavement in recent years. It is reported that the production process of asphalt mixture using warm mix additives (including Sasobit et al.) can reduce the construction temperature, fuel consumption, and mitigate the impact on air pollution(Ruiz et al., 2014 and 2015). Jamshidi et al. (2012) studied the rheological characteristics of Sasobit modified asphalt. Wu and Zeng (2012) studied the performance grades of Sasobit modified asphalt and reported that Sasobit has a stiffening effect on the grading temperatures. Zelelew et al. (2013) reported that the mixtures prepared with Sasobit give higher stiffness, a higher dynamic modulus rutting parameter, and a higher fatigue cracking parameter than that of the other warm-mix types. Li et al. (2015) studied the influence of Sasobit on the properties of SBS modified asphalt, Including softening point, temperature sensitivity and viscosity et al. Kök and Akpolat (2015) reported that Sasobit can improve the effectiveness of SBS modification, especially at medium to high temperatures. Fan et al. (2015) evaluated the effects of Sasobit on the rheological properties of asphalt by dynamic shear rheometer. He et al. (2015a) reported that the high-temperature creep performance of Sasobit rubber asphalt is better than that of SBS modified asphalt. Wu (2015) studied the viscosity reduction mechanism of Sasobit on rubber asphalt through experiments. He et al. (2015b) evaluated the rheological properties of Sasobit warm mix rubber asphalt in the wide range of pavement temperature at high (60, 70℃), medium (25℃) and low (5℃--24℃) temperatures. Xiao et al. (2009) reported that the WMA additive can reduce the mixing and compaction temperatures of rubberized asphalt mixtures and

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extend the long-term performance of pavement. By studying the rheological and chemical characteristics of asphalt rubber (AR) binders modified with four warm mix asphalt (WMA) additives, Yu et al. (2016) reported that all selected WMA additives are effective in enhancing AR's workability.

Most of the existing studies are for Sasobit ordinary asphalt and modified asphalt, and studies on Sasobit warm mix rubber asphalt are relatively few. In order to reveal the influences of Sasobit on rubber asphalt, this paper studied the technical characteristics of Sasobit warm mix rubber asphalt through Sasobit rubber asphalt performance tests and preparation process test of Sasobit asphalt rubber.

2. Introduction of Sasobit warm mix agent

Sasobit is an organic compound viscosity reducer, which is made by using Fischer-Tropsch (FT) method in the vaporization of coal. The melting point of Sasobit is about 99 degrees, and when more than 116 degrees it can completely dissolve in the asphalt binder, resulting in a large number of liquid to reduce the viscosity of asphalt binder. When the environment temperature is lower than the melting point, the lattice structure of Sasobit formed in the asphalt cement will help improve the stability of the asphalt cement, therefore, in the asphalt pavement temperature, the ability to resist permanent deformation of asphalt concrete pavement is enhanced.

3. Effects of Sasobit on the performance of rubber asphalt

3.1 Test materials

Matrix asphalt is Singapore's 90 A-grade road asphalt, and its main technical indexes are shown in Table 1. The main technical indexes of rubber powder (particle size of 30 meshes) are shown in Table 2 (content for mass fraction in the Table). The appearance of Sasobit is small solid particles (Figure 1), and its physical properties are shown in Table 3.

Table 1: Main technical indexes of matrix asphalt

Items	Density(25 ℃)/($g·cm^{-3}$)	Penetration(25 ℃)/(0.1 mm)	Ductility (15 ℃)/cm	Softening point /℃
Test results	1.034	97	>100	45.7

Table 2: Main technical indexes of crumb rubber

Items	Water	Metal	Fibre	Ash	Acetone extract	Carbon black	Rubber hydrocarbon
Content /%	0.62	0	0.01	7.6	6.6	28	63
Requirement /%	<1.00	<0.05	<1.00	≤8.0	≤16	≥28	≥42

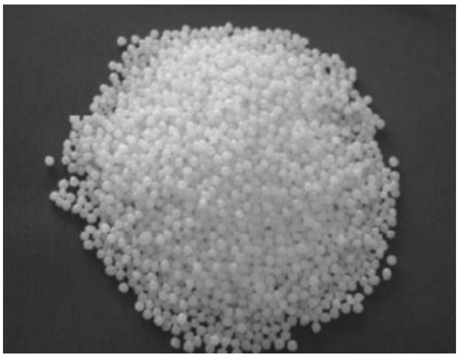

Figure 1: Sasobit particles

Table 3: Physical properties of Sasobit

Items	Drop melting point /℃	Flash point /℃	Viscosity（135 ℃）/（10^{-3}Pa. s）	Density（25 ℃）/（$g·cm^{-3}$）
Typical value	115	290	12	0.94

3.2 Test scheme

Production requirements (according to project's requirements) of rubber asphalt are as follows: rubber powder accounts for 21 % of the mass of the asphalt; reaction temperature is 180 ℃ and reaction time is 45 min. Adding 1.5 %, 2.0 % and 3.0 % (mass fraction) of Sasobit into the finished rubber asphalt respectively, the performance indexes (Table 4) of rubber asphalt are tested before and after adding Sasobit.

Table 4: Performance indexes of rubber asphalt

Indexes	Test methods	Technical requirements
Rotary viscosity(180℃)/(Pa·s)	—	1.5~4.0
Softening point (R & B) /℃	JTG T0606	≥60
Cone penetration(25℃)/0.1 mm	ASTM D217	25~70
Resilience(25℃)/%	ASTM D5329	≥25
Ductility(5℃,5 cm/min)/cm	JTG T0605	≥5

3.3 Test results and analysis

The test results and the change rates of the performance indexes of rubber asphalt before and after adding Sasobit are shown in Table 5. The comparisons of performance indexes are shown in Figure 2.

Table 5: Test values and change rates of performance indexes before and after adding Sasobit

Indexes	1.5 % Sasobit			2.0 % Sasobit			3.0 % Sasobit		
	A	B	C	A	B	C	A	B	C
Rotary viscosity(180 ℃)/(Pa·s)	3.58	3.15	-12.0	3.55	2.83	-20.3	3.77	2.67	-29.2
Softening point (R & B) /℃	66.8	77.8	+16.5	64.1	75.0	+17.0	65.6	86.7	+32.2
Cone penetration(25 ℃)/0.1 mm	39.6	36.3	-8.3	41.3	37.5	-9.2	45.4	40.9	-9.9
Resilience(25 ℃)/%	30.0	31.6	+5.3	29.2	29.1	-0.3	31.2	30.5	-2.2
Ductility(5 ℃,5 cm/min)/cm	6.6	4.5	-31.8	6.9	4.5	-34.8	7.4	4.7	-36.5

Notes: A --Before adding Sasobit; B --After adding Sasobit; C --Change rates after adding Sasobit (%).

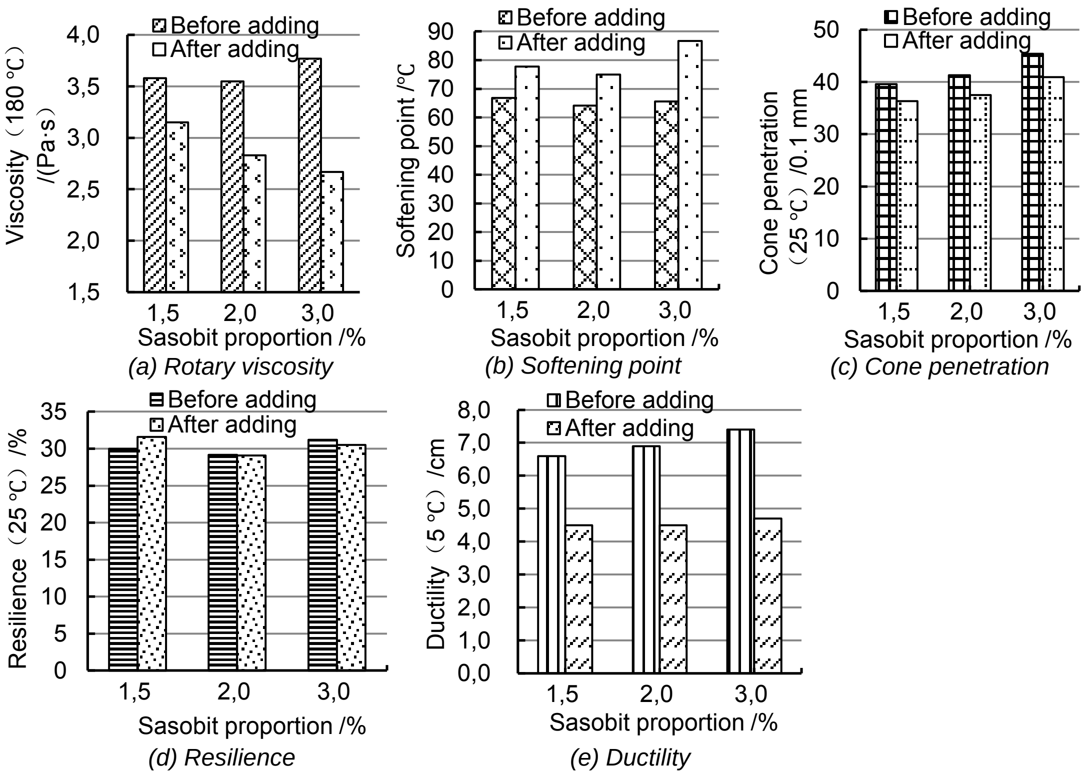

Figure 2: Contrast of performance indexes before and after adding Sasobit

Figure 2 (a) shows that the rotational viscosity of rubber asphalt significantly reduced after adding Sasobit, and the greater the proportion of Sasobit, the greater the reduction of viscosity. Figure 2 (b) shows that the softening point significantly improved after adding Sasobit. Sasobit can adsorb saturated components (mostly wax base or oil-based molecules) with the similar structure in rubber asphalt at high temperature. When the temperature decreases, Sasobit and saturated components adsorbed crystallize together, and form a stable crystal structure, which can improve the softening point of rubber asphalt. Figure 2 (c) shows that the cone penetration (25°C) decreased to some extent after adding Sasobit, that is to say, the hardness of rubber asphalt was slightly larger. Figure 2 (d) shows that the resilience (25°C) changed little after adding Sasobit, and the effect of Sasobit on the resilience (25°C) of rubber asphalt is not obvious. Figure 2 (e) shows that the ductility (5°C) significantly reduced after adding Sasobit. Because the main component of Sasobit is hard wax, and the wax molecules dissolved form coarse crystal in low temperature, which leads to the ductility of rubber asphalt decreases. It needs to be explained that the performance of the finished rubber asphalt is affected by many factors, so the performance index values of rubber asphalt tests (before adding Sasobit) were not completely equal every time.

The change rates of performance indexes in Table 5 are uniformly expressed together as shown in Figure 3.

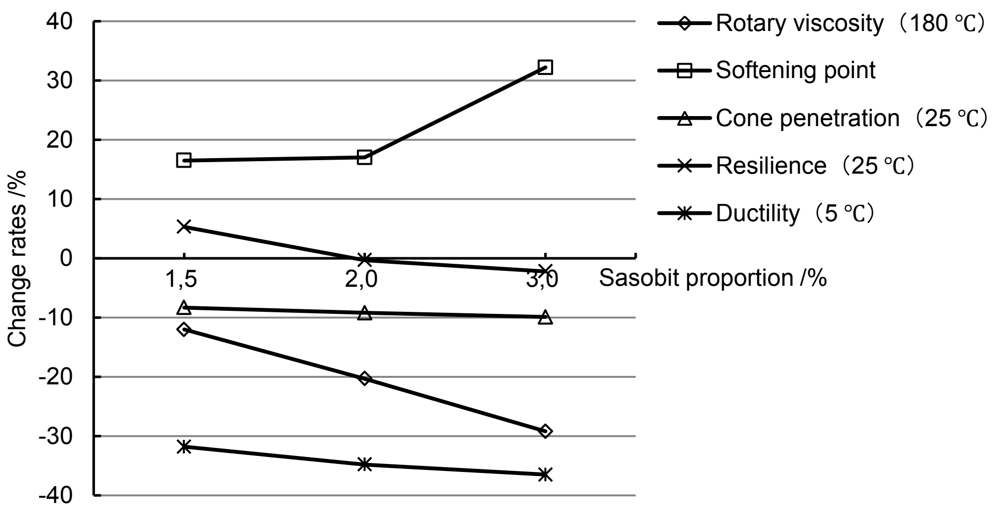

Figure 3: Contrast of change rates of performance indexes

Figure 3 shows: with the increase of the proportion of Sasobit, the rotational viscosity (180°C) and ductility (5°C) of rubber asphalt significantly reduced, and softening point increased, resilience (25°C) and cone penetration (25°C) changed very little. The averages (absolute value) of change rates of performance indexes from large to small are as follows: ductility, softening point, viscosity, cone penetration and resilience.

From above analysis, it can be known that the main effects of Sasobit on the performance of rubber asphalt are: Sasobit significantly reduces the high-temperature viscosity of asphalt rubber, which can increase the workability; dramatically increases the softening point which can enhance the high-temperature stability of rubber asphalt; markedly reduces the low temperature ductility of rubber asphalt.

4. Effects of Sasobit adding process on the performance of rubber asphalt

In the previous experiments, Sasobit rubber asphalt was prepared by adding Sasobit into the finished rubber asphalt. In this section, test of changing preparation process of Sasobit rubber asphalt is carried out: Sasobit is firstly added into the hot matrix asphalt, after mixing evenly, adding the rubber powder, by stirring constantly at prescribed temperature and after predetermined reaction time to obtain Sasobit rubber asphalt. By this way, the effect of Sasobit adding process on the performance of rubber asphalt is studied.

The experiment program of adding Sasobit (2.0% of the rubber asphalt quality) into the finished rubber asphalt is called working procedure A (test results are shown in Table 6), and the experiment program of adding Sasobit (2.0% of the rubber asphalt quality) into the hot asphalt and then adding rubber powder is called working procedure B here. The test results of working procedure B and the comparison with working procedure A are shown in Figure 4.

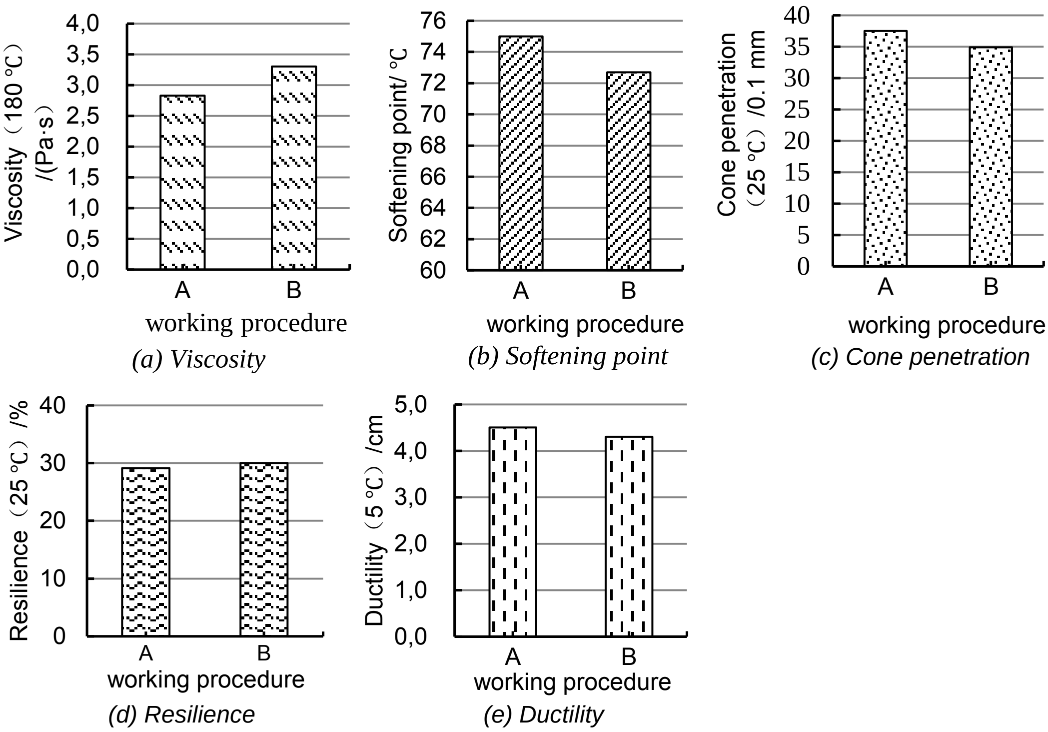

Figure 4: Performance comparison of the two working procedures

Figure 4 shows: compared to working procedure A, the Sasobit rubber asphalt prepared according to working procedure B has higher viscosity, lower softening point and cone penetration, little difference in other indexes. These performance changes of Sasobit rubber asphalt prepared according to working procedure B should be related to this reason: Sasobit had existed in the high-temperature rubber asphalt for long time, resulting in reduction or partial failure of the chemical composition in it.

The main function of Sasobit is to reduce the high-temperature viscosity of rubber asphalt in order to increase the construction workability, or in the case of lower temperature asphalt rubber still has good construction workability. Due to the higher viscosity and lower softening point, workability and high-temperature stability of Sasobit rubber asphalt prepared according to working procedure B are not as good as those of according to working procedure A. So in actual construction, preparation of Sasobit rubber asphalt should be carried out in accordance with working procedure A.

5. Conclusions

In this paper, the effects of Sasobit warm mix agent on the performance of rubber asphalt are studied. Through experimental study, the following conclusions are obtained:

(1) Sasobit warm mix agent can significantly reduce the high-temperature viscosity and low-temperature ductility, and improve the softening point of rubber asphalt, which have help to improve construction workability and high-temperature stability of rubber asphalt, but have adverse effect on low-temperature performance of rubber asphalt. Effects of Sasobit on resilience and cone penetration of rubber asphalt are not big.

(2) The preparation process of adding Sasobit into matrix asphalt before adding rubber powder compares with the preparation process of adding Sasobit into the finished rubber asphalt: the viscosity of Sasobit rubber asphalt is larger and the softening point is smaller, so the workability and high-temperature stability of Sasobit rubber asphalt are not as good as the latter process. Sasobit rubber asphalt should be prepared by adding Sasobit into the finished rubber asphalt in construction.

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