Study on the Effect of Sulfur on the Thermal Storage Stability of SBS Modified

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***Abstract*— SBS modified asphalt has become one of the main materials of road construction, Its quality has a very important impact on the performance of the road. The heat storage stability of SBS modified asphalt is a key factor affecting its quality. The research on the effect of sulfur on performance of SBS modified shows that the addition of sulfur improves the softening point of SBS modified asphalt, improve the compatibility of SBS and matrix asphalt, improve the heat storage stability of SBS modified asphalt.**

***Index Terms*— sulfur SBS modified asphalt softening point heat storage stability**

I. INTRODUCTION

Asphalt material has been widely used in high-grade highways due to its excellent performance. The cohesiveness and plasticity of asphalt can adapt to various forces on the raod come from the vehicle. It has abundant resources which make it have a strong guarantee in popularization in the road engineering and has gradually became the main material required for road construction. But the traditional matrix asphalt has some common performance defects like temperature sensitivity, poor anti-aging performance, easily brittle broken in low temperature and easy to flow in high temperature , and so on. It seriously affects the durability and service life of the road. The volume of traffic has increased rapidly cause of the accelerating pace of economic growth. The gradually improved of infrastructure construction which make a strict request on quality of road construction materials. The above situation has stimulated the development of high quality asphalt especially modified asphalt. The SBS modified asphalt can solve some defects of the matrix asphalt which make it gradually become the main building materials in the road[1]. But the compatibility of SBS with matrix asphalt is poor. The fusion between SBS and matrix asphalt is only physical compatibility. Segregation phenomenon will happen in the process of high temperature storage which is seriously affecting the road performance of SBS modified asphalt. Through the physical methods can only promote the miscibility between SBS and matrix asphalt to a certain degree. It can not be a good solution to the segregation phenomenonhigh in the process of high temperature storage. To improve this problem, the sulfur is used as the stabilizer. The effect of sulfur on the performance of SBS modified asphalt was studied.

II. THE TRIAL PART

1.1 Trial material

Use 70 # asphalt as the matrix asphalt. The performance indicators of 70 # asphalt as shown in Table 1. Modifier used as Star / linear = 1/4. The stabilizer is the elemental sulfur with 98% pure.

Table 1 The performance indicators of 70 # asphalt

Inspection Items	Determination
Softening Point（℃）	50.1
Penetration（0.1mm，25℃）	71.2
Ductility（5cm/min,10℃.cm）	44.2
Viscosity（Pa.s,60℃）	195.4
flashpoint of asphalt/℃	273
Penetration ratio/%	61.5
mass loss/%	0.56
residual ductility (10℃)/cm	8.1
residual ductility (15℃)/cm	18

1.2 Sample preparation

Add the compatibilizer(3%) that has been weighed when the matrix asphalt was heated to 175℃. Then put the SBS modifier particles (4%) into the matrix asphalt. After that, place the enamel cup with a mixture of matrix asphalt, SBS modifier and compatibilizer on the heater. Place and open the shear instrument shear. Then shear on speed of 3000 r/min. The SBS modified asphalt will be producted after 30 minutes. Set four groups of trial, control the content of sulfur as the only variable. The content of sulfur in the four groups are 0%, 0.45%, 0.6%, 0.75% of the total mass of matrix asphalt. The content of SBS is 4% of the total mass of matrix asphalt and the compatibilizer is 3%. The details are shown in Table 2.

Tab.2 The trial details of each group

Inspection Items	Content(the Percentage of sulfur in total amount of matrix asphalt)/%
A	0
B	0.45
C	0.6
D	0.75

1.3 Performance test of modified asphalt

1）Routine test

Although the physical properties and mechanical properties of polymer modified asphalt have changed compared to matrix asphalt, the basic properties are similar to those of

conventional asphalt. Therefore, the performance of polymer modified asphalt can also be measured by the conventional performance index of asphalt. This includes mainly high temperature performance, low temperature performance, stability and durability, including softening point, 135 ℃ rotational viscosity, which low temperature performance, including 5 ℃ ductility. In addition, the compatibility of modified asphalt can be evaluated using the high temperature storage stability (48h segregation test) of modified asphalt. That is selected the most basic indicators of sprinkling: softening point, 5 ℃ ductility, 25 ℃ penetration and modified green 25 ℃ elastic recovery, 135 ℃ rotational viscosity.

2）Thermal storage stability test

The thermal storage stability of the modified bitumen can be evaluated by a segregation test. Immediately prepared modified asphalt into the sample tube, the sample tube for 175 ℃ ± 5 ℃ oven, after 48h still removed, and the sample tube placed in the refrigerator at -10 ℃, during the period is not allowed to shake or tilt the sample tube, frozen for 3 hours to freeze into a solid. And then the average sample tube cut into three points, take the top and bottom part of the softening point test, record the difference. The smaller the difference, the better the stability of modified asphalt [3].

III. Test Results and Analysis

2.1The effect of sulfur on high temperature performance of modified asphalt

The data of penetration and softening point of SBS modified asphalt are shown as shown in Table 3. The influence trend is shown in figure 1.It can be seen from the figure that the softening point of modified asphalt is increased by the addition of sulfur, and the softening point continues to show an upward trend with the increase of sulfur.But the trend gradually slowed down, while making the modified asphalt penetration slightly reduced.The effect of sulfur on the performance of modified asphalt is mainly due to the fact that sulfur reacts with the asphalt to produce the crosslinked material to change the asphalt molecular chain from the two-dimensional structure to the three-dimensional network structure. The relative slip between the molecular chains in the asphalt is constrained ,so that the viscosity of asphalt was increased, the penetration was reduced, high temperature resistance to flow was enhanced, the modified asphalt shows a strong high temperature stability.

Tab.3 Conventional test data of modified asphalt

Inspection Items	A	B	C	D
Phenomenon	uncemented	uncemented	uncemented	cementitious
Softening Point/℃	50.1	75.4	76.0	77.5
Penetration/（10^{-1}mm）	71.2	70.2	71.0	71.3
Ductility（10℃）/cm	44.2	43.5	41.2	40.1
Kinematic viscosity（135℃）/（Pa·s）	—	1.934	1.938	1.939

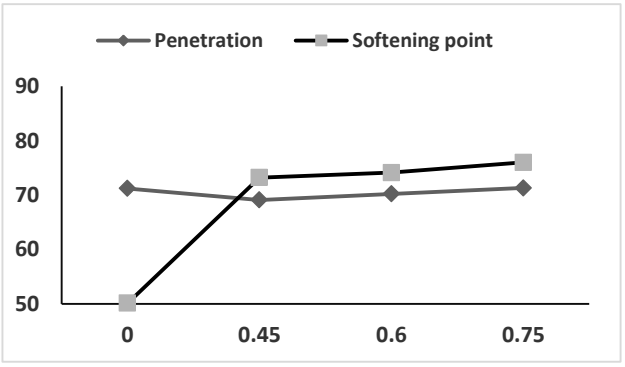

Fig.1 Effect of sulfur content on softening point and penetration of modified asphalt

2.2 The effect of sulfur on low temperature performance of modified asphalt

Figure 2 shows that the effect of different content of sulfur on low temperature performance of modified asphalt.It can be seen from Fig. 2 that the ductility of the modified asphalt decreases with the increase of the sulfur content.The sulfur content is inversely proportional to the size of the ductility, that is, the low temperature performance is declining.

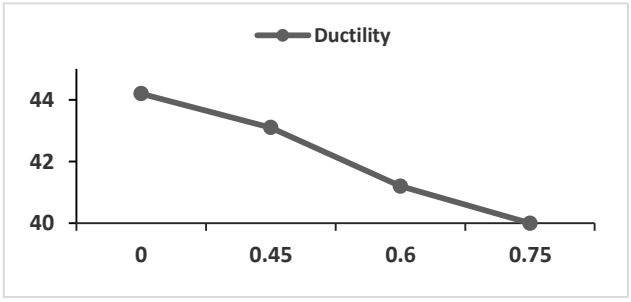

Fig.2 Effect of sulfur content on ductility of modified asphalt

2.3 Effect of Sulfur on Heat Storage Stability of Modified Asphalt.

Heat storage stability is one of the important indicators to measure the quality of modified asphalt. Poor stability will cause stratification and reunification phenomenon. It is seriously affect the qualities of modified asphalt. It's qualities are not uniform, which will affect the performance of modified asphalt directly.

Table 4 shows the effect on the heat storage stability of modified asphalt with adding different amounts of sulfur. It can be seen from Figure 2 that the difference of modified asphalt segregation softening point reached 49.5 ℃ without adding sulfur and the stratification phenomenon of modified asphalt is extremely serious. Heat storage stability does not meet the regulatory requirements. The difference of modified asphalt segregation softening point is narrowing gradually and the performance of modified asphalt tends to be smooth after adding the sulfur. After adding the sulfur stabilizer, a stable phase interfacial adsorption layer is formed between the polymer phase in the modified asphalt and the matrix asphalt phase. It reduces the surface tension of the interface and increase the affinity between the two phases. Which promote compatibility between the two phases, improve the efficiency of SBS utilization and reduce the amount of SBS. It significantly improve the thermal stability of modified asphalt. Considering the quality such like softening point, penetration and ductility of the asphalt after adding stabilizer, the sulfur content was determined to be 0.6%.

IV. CONCLUSION

(1) Adding a certain amount of sulfur can improve the softening point of modified asphalt.
(2) The addition of sulfur has little effect on the penetration of modified asphalt
(3) The addition of sulfur significantly improved the compatibility of the modifier with the matrix asphalt and improved the thermal storage stability of the modified bitumen.

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