

# Study on the Change Law of Performance and Regeneration Mechanism of Aging SBS Modified Asphalt

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## Abstract

This paper starts from the research status of SBS modified asphalt aging and regeneration mechanism at home and abroad, and summarizes the performance change law and regeneration mechanism of SBS modified asphalt. Asphalt aging is the main factor that affects the durability of asphalt pavement, and then reduces the service life of the pavement. Through the analysis of the aging status of SBS modified asphalt, the performance change law of aging SBS modified asphalt is analyzed from the microscopic and macroscopic perspectives. The influence factors of multiple aging, rejuvenating agent and regeneration method on the regeneration mechanism of aging SBS modified asphalt. The study of asphalt performance provides reference and reference.

## Keywords

Road Engineering; SBS Modified Asphalt; Aging; Regeneration Mechanism.

## 1. Preface

According to statistics, by 2020, the total mileage of highways in China has exceeded 5.1 million kilometers, of which the mileage of expressways has reached more than 150,000 kilometers, ranking first in the world. In the past two years, on the basis of attaching importance to highway construction, my country has increased the research on the regeneration mechanism of aging asphalt pavement. At present, cracks, ruts and other diseases on roads are caused by the aging of asphalt pavement, and SBS modified asphalt can improve the service life of roads and various parameters on the basis of ordinary asphalt. Therefore, SBS modified asphalt is used more and more widely at present, but it is undeniable that SBS modified asphalt also has the phenomenon of aging. Therefore, it is more and more important to increase the research on the aging behavior and regeneration mechanism of SBS modified asphalt. Based on the research on the aging and regeneration mechanism of SBS modified asphalt at home and abroad in the past 20 years, this paper makes a summary and prospect.

## 2. The Aging Status of SBS Modified Asphalt:

SBS modified asphalt is an SBS blend material made by adding a certain proportion of different types of SBS modifiers to the base asphalt. Compared with ordinary asphalt modification, important parameters have been improved, including penetration, softening point, ductility, toughness and other parameters, among which the improvement of low temperature ductility and softening point can be significantly improved. Temperature Sensitivity of Asphalt Pavements. Therefore, the improvement of parameter indicators can alleviate the phenomenon of pavement aging, effectively reduce and avoid pavement diseases, and improve road performance. However, SBS modified asphalt pavement will still age and cause pavement diseases after long-term use. Based on the principle of saving resources and reducing costs, the aged asphalt pavement still has the value of recycling. Therefore, it is necessary to fully understand the SBS modification. The aging characteristics of asphalt can be used to regenerate

pavement more effectively. Based on different stages of asphalt pavement aging, SBS modified asphalt has three stages of aging: production and transportation, construction and laying, and putting into use. At the same time, it shows that the aging of modified asphalt is divided into two parts: matrix asphalt and modifier. The aging of the agent is reflected in the oxidative decomposition of SBS. Zhang Jun [1] et al. further elaborated that oxidation reaction occurred in the aging process of base asphalt. Different from the base asphalt, there is polybutadiene fracture on the basis of oxidation reaction in the aging process of modified asphalt. After fully understanding the aging mechanism of modified asphalt, improving the parameter indicators through different experiments can improve the recycling rate, save the construction cost, effectively alleviate the unnecessary waste of resources, and then promote the sustainable development of the environment.

### 3. Change Law of Aging Performance of SBS Modified Asphalt

The aging law of SBS modified asphalt includes macroscopic and microscopic laws. Changes in content and microscopic shape and micromechanical properties.

**Table 1.** Technical requirements for SBS modified asphalt

index	unit	SBS Class ( Class I )			
		I-A	I-B	I-C	I-D
Penetration 25 ° C	1/10mm	>100	80-100	60-80	30-60
Ductility 5 ° C (greater or equal to)	cm	50	40	30	20
Softening Point (greater or equal to)	°C	45	50	55	60
Kinematic viscosity 135 ° C (less than or equal to)	Pa.s	3			
Elastic recovery 25 ° C (greater or equal to)	%	50	60	65	75
Toughness (greater than or equal to)	N.m	-			
quality change (less than or equal to)	%	1.0			
Residual Penetration Ratio 25 ° C (greater or equal to)	%	50	55	60	65
Ductility 5 ° C (greater or equal to)	cm	30	25	20	15

#### 3.1. Analysis of Change Laws From a Macro Perspective

Many scholars use indoor film aging experiments to simulate the aging process of SBS modified asphalt, and change the amount of SBS modifier, and compare the four technical indicators of penetration, rotational viscosity, ductility, and elastic recovery. The technical indicators of modified asphalt have a certain relationship with the content of SBS modifier, and it is further pointed out that when the content of SBS modifier is 4%, the high temperature performance is good, and it has low temperature sensitivity, then Its anti-aging ability is the best. At the same time, according to the influence of storage temperature of SBS modified asphalt on macroscopic technical indicators, Yu Lei [2] and others designed three storage solutions at different temperatures: 1. After storage at room temperature, heat it to 170 ° C before testing; 2. 140 ° C After storage, continue to put it in the oven for preservation, and then heat it to 170 ° C for testing; 3.170 ° C for transportation, then wait for the temperature to drop to 140 ° C, and then

put it in 170 °CStore in an oven, and compare the technical index changes of the three schemes. The test shows that the penetration, ductility, viscosity and softening point continue to decrease with the increase of time. For the third group of experimental conditions, the storage time should be controlled within three days, and for the second group of experimental conditions, the time can be increased to the third. Five days. In order to determine the effective evaluation index of SBS aging asphalt, the penetration, softening point and rutting factor of SBS aging asphalt were observed through dynamometric ductility, dynamic shear and routine tests . The correlation of aging time of SBS modified asphalt was analyzed. Experiments show that the indexes such as penetration, softening point and rutting factor cannot effectively evaluate the aging characteristics of SBS modified asphalt, and toughness is the only index that can effectively evaluate the aging characteristics [3] .

### 3.2. Analysis of Change Laws from a Microscopic Perspective

The microscopic angle includes changes in chemical composition and microstructure. This paragraph focuses on chemical composition. The main methods are to observe and analyze the change law of oxygen absorption degree and molecular composition of SBS modified asphalt using microscopic experiments such as infrared spectroscopy and gel chromatography . The experimental results show that the aging of SBS modified asphalt can be divided into two stages: the oxygen absorption rate gradually increases from a low level and the proportion of small molecules decreases gradually. , the proportion of small molecules is about to begin to decrease. At the same time, the microscopic analysis method of infrared spectroscopy can also find that the SBS modified asphalt exhibits a deoxidation reaction during the aging process, and a large number of unsaturated carbon-carbon double bonds are formed. The aging rate of the SBS modified asphalt is higher than that of the matrix asphalt. However , the aging degree of SBS modified asphalt is lower than that of base asphalt.

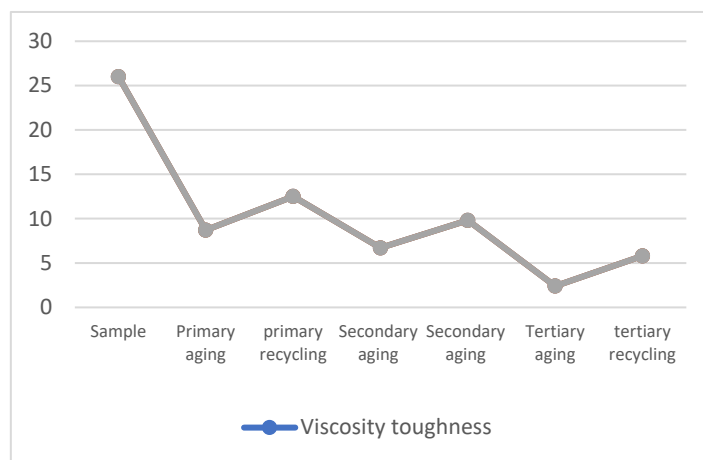
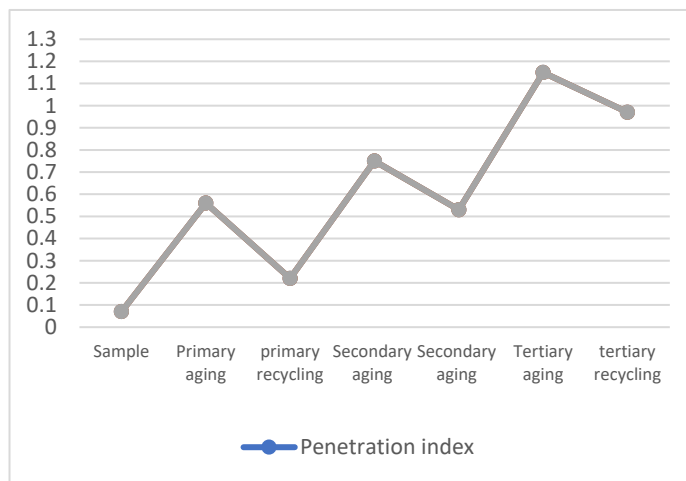
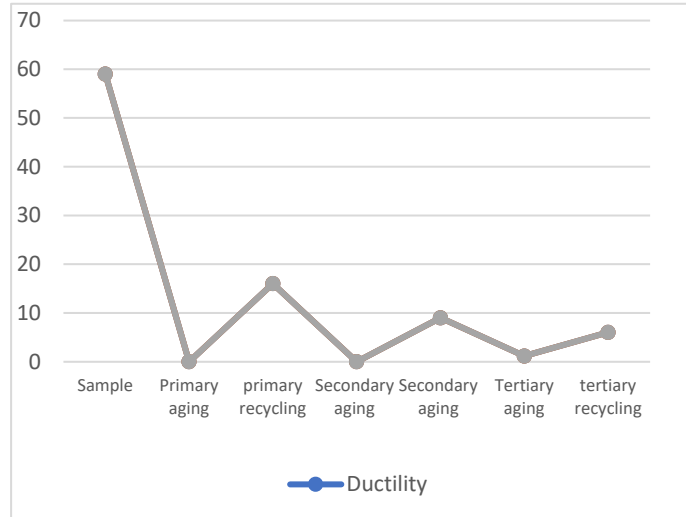
According to the current research results, it is not difficult to find that the aging of SBS modified asphalt has a great impact on its macro technical indicators, which are specifically reflected in the decrease in penetration, viscosity and toughness, and increase in viscosity, softening point, and rutting factor. At present, the focus of the research is still on the macroscopic law, but the research on the macroscopic aspect is still at a relatively superficial stage, and the classification standard of aging characteristics has not yet been determined. The research on the comprehensive analysis of its chemical composition and microstructure should be increased. Emphasis is placed on analyzing the changing law of the aging of SBS modified asphalt from a microscopic perspective, and a more comprehensive summary of the aging law of SBS modified asphalt is combined with the microscopic and macroscopic aspects .

## 4. Research Status of Regeneration Mechanism of Aged SBS Modified Asphalt

Darange [5] et al. regenerated the recycled aged SBS modified asphalt, and measured its performance after regeneration. The results found that the recycled asphalt still has good performance, so it shows that the aged SBS modified asphalt can be treated with certain experimental methods. for recycling. In recent years , SBS modified asphalt pavement has entered a large number of stages that need to be refurbished or rebuilt. Therefore, in order to save costs and resources, many scholars have increased the research on the regeneration mechanism of aging SBS modified asphalt. This chapter mainly introduces three different factors that affect the regeneration of SBS modified asphalt.

### 4.1. Influence of Multiple Aging and Regeneration on the Regeneration Mechanism of Aging SBS Modified Asphalt

**Table 2** Experimental results



The technical indicators such as penetration, ductility, elastic recovery performance and other technical indicators have been regenerated for many times, and the following conclusions are drawn: with the increase of aging and regeneration times, the technical indicators of modified

asphalt continue to decline, and the recovery of primary and secondary regeneration indicators is relatively high. Good, but after three or more regenerations, the penetration index increases and the ductility, viscosity and toughness decrease (see Table 2 for details ), so the SBS modified asphalt can be used as ordinary asphalt. Zou Guilian also mentioned that the asphalt and the regenerant were fully mixed in the experiment, but other factors will affect the mixing degree in the actual construction process, so the regeneration effect of the actual project will be further reduced [6] .

After that , the DMA method was used to further study the SBS modified asphalt that was regenerated for many times . It was found that the SBS compatibilizer could not decompose the SBS modifier again, so it could not improve the compatibility of SBS and asphalt. In addition, the rheology and its durability after multiple regenerations were mainly observed by bending rheological experiments, and regression analysis was carried out. It was found that the original creep slope was 0.455 at -5 ° C , and the m value increased after three regenerations. When it reaches 0.552 , the SBS modified asphalt with multiple regenerations has better low temperature resistance, but when the regeneration times continue to increase, the original asphalt mortar and the creep slope ( m value) are more discrete.

#### 4.2. Influence of Different Regenerant Types and Dosages on the Regeneration Mechanism of Aged SBS Modified Asphalt

On the basis of combining the modification ideas of ordinary asphalt, the modified asphalt is modified again with different modifier addition ratios (see Table 3 ) . The rate of increase and decrease is the slowest; the softening point, ductility and elastic recovery rate gradually increase. It shows that TPS modifier can not only improve the low temperature performance but also greatly help the high temperature stability of modified asphalt, so TPS modifier is a better choice [7] .

**Table 3.** Additive ratio of different additives

additive	add scale, %					
	0	3	6	9	12	15
TPS	0	3	6	9	12	15
Ref 8000	0	4	7	10	13	16
will fit	0	1	2	3	4	5

**Table 4.** SBS modified asphalt as-is, short-term aging, after regeneration

sample	Penetration (25°C,100g,5s)	Elongation (5cm/min,15 °C)	Softening point / ° C
SBS modified asphalt	73.5	42.2	78.3
short term aging SBS modified asphalt	53.2	22.8	85.1
+4% XK modifier regeneration	67.8	35.9	82.5
+8% XK modifier regeneration	78.4	55.4	75.3
+12% XK modifier regeneration	79.1	56.1	74.6

Similar to the above-mentioned experimental type, two different types of rejuvenating agents were used, and various reclaimed asphalts were prepared by changing their content. The

macroscopic and microscopic analysis of SBS reclaimed asphalt was carried out, and it was found that the content of rejuvenating agent was 8% on the improvement of aging SBS modified asphalt the most obvious (the index changes are shown in Table 4 ). It is obviously better than the regenerated SBS modified asphalt formed by diffusion under the action of regenerant [8] .

### 4.3. Influence of Different Regeneration Methods on the Regeneration Mechanism of Aged SBS Modified Asphalt

Based on repeated loading experiments, the research shows that the proportion of old SBS modified asphalt has the most obvious effect on the fatigue life of recycled SBS modified asphalt, and the recommended proportion does not exceed 35% . And put forward a suggestion that the elastic recovery index is the most important index to evaluate the regeneration fatigue performance of SBS modified asphalt, which also points out the direction for future research. Secondly, the aged SBS modified asphalt was regenerated by three different ways: new base asphalt, rejuvenating agent and new modified asphalt, and the changes of parameters were observed. The experimental results show (as shown in Table 5 ): the regeneration effect of the newly modified asphalt is better than the other two regeneration methods.

**Table 5.** Technical indicators of aged SBS modified asphalt and recycled asphalt

	Brookfield Viscosity /(mPa.s)	Softening point /°C	Penetration ( 0.1mm )	Elongation /cm
Aged SBS Modified Asphalt	3037	76.6	34.7	-
Add regenerant	1086	58.6	61.2	15.2
Add base asphalt	771.5	54.7	64.4	16.5
Add new SBS modified bitumen	1394.4	64.6	68.1	34.7

Further, Li Lihan adopted two design schemes (adding regenerant or base asphalt, adding regenerant and SBS modified asphalt) to regenerate SBS modified asphalt with three aging degrees , and found that according to macroscopic technical indicators and microstructure changes: For SBS - modified asphalt with a light aging degree , adding too much regenerant or matrix asphalt will reduce the cross-linking effect between SBS and matrix asphalt, thereby reducing its toughness; and for SBS - modified asphalt with a deep aging degree, use The effect of rejuvenating agent adding new SBS modified asphalt is the best, so that the technical indicators such as penetration are close to the SBS modified asphalt before aging [9] .

## 5. Conclusion

In order to further promote the research on the change law of performance and regeneration mechanism of aging SBS modified asphalt, this paper reviews the analysis of the change law of macroscopic technical indicators and microstructure of aging SBS modified asphalt by scholars in the past 20 years , as well as the different factors affecting its regeneration mechanism. Research. And put forward the following summary and outlook:

(1) In recent years, there have been many studies on macroscopic performance, but it is difficult to form a unified and determined evaluation index. The technical indicators after aging are still to be investigated, and more in-depth research is required. In addition, the relationship between macro performance, micro chemical composition and micro structure should be

established more comprehensively to observe the change law of SBS modified asphalt performance more comprehensively.

(2) As the current SBS modified asphalt pavement needs a lot of renovation and reconstruction, the research on the regeneration law of the aged SBS modified asphalt pavement is more and more important, and the previous focus on the effect of different types of rejuvenating agents and dosage on the regeneration mechanism, from the micro and macro perspectives to find the criteria for determining the best type of regenerant. In order to clarify the unified evaluation system of the regenerant, the research on different regeneration methods and times of regeneration has been increased in the later stage, as well as the SBS modified asphalt with different degrees of aging. Using more targeted methods, we will continue to find and study more effective ways to extend the service life of roads, reduce costs and save resources.

(3) In the future, the effect of adding different proportions of rejuvenating agent and new SBS modified asphalt on the regeneration mechanism of aged SBS modified asphalt can be further studied on the basis of aging SBS modified asphalt.

## References

- [1] Zhang Jun, Liao Kejian, Yan Feng, Jiang Diandong. Analysis of aging performance of base asphalt and SBS modified asphalt [J]. Petrochemical Technology and Application. 2008, 26 (3): 237-239.
- [2] Yu Lei, Huang Fei, Qian Xihong. Study on storage performance of SBS modified asphalt [J]. Journal of Suzhou University of Science and Technology (Engineering Technology Edition). 2020, 33 (S1): 63-68.
- [3] Qi Wenyang, Li Lihan, Wang Yukai. Evaluation index of aging characteristics of SBS modified asphalt based on dynamometric ductility test [J]. Journal of Building Materials. 2014, 17(3): 543-547.
- [4] ZHAOYL, GU FXU J, et al. Analysis of Aging Mechanism of SBS Polymer Modified Asphalt Based on Fourier Transform Infrared Spectrum [J]. Journal of Wuhan University of Technology (Materials Science Edition), 2010, 25(6): 1047-1052.
- [5] DARANGA C. Characterization of aged polymer modified asphalt cements for recycling purposes [D]. Bato Rouge: Louisiana State University, 2005.
- [6] Zou Guilian, Yan Ran, Zhang Chen. Multiple Regeneration Evaluation Based on SBS Modified Asphalt Characteristic Index [J]. Road Construction Machinery and Construction Mechanization. 2017, (34): 59-63.
- [7] Zhang Daoyi, Qu Yanbin, Zhao Yongli, Xu Qiubin. Feasibility Analysis of Modified Recycled Asphalt [J]. Petroleum Asphalt. 2008, 22(1): 69-71.
- [8] Zhang Xingjun, Feng Huixia, Wang Yongning, Li Bo, Zhang Zhihao. Microscopic mechanism of short-term aging SBS modified asphalt regeneration based on infrared spectroscopy [J]. Chinese Journal of Materials Science and Engineering. 2020, 38(2): 232-237.
- [9] Li Lihan, Zhang Mingjie, Qi Wenyang. Regeneration and mechanism analysis of aged SBS modified asphalt [J]. Journal of Chang'an University (Natural Science Edition). 2017, 37(3): 1-8.