*Hydraulic and Civil Engineering Technology VIII*
*M. Yang et al. (Eds.)*

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*doi:10.3233/ATDE230783*

# Laboratory Investigation on the Effect of Warm Mixing Agent on Low Temperature Performance of Base Asphalt

Shaopeng LIU [a] and Fuqing YUE [a,1]
[a] *Transport Planning and Research Institute, Ministry of Transport, Beijing, China*

**Abstract.** The properties of asphalt materials have a significant impact on the quality and performance of road surfaces. Asphalt materials are the main factor affecting low-temperature cracking of road surfaces. The low-temperature performance of asphalt and asphalt mixtures has a significant impact on the quality and service life of road surfaces in northern and central China. SHRP research results suggest that asphalt contributes 80% to the cracking resistance of asphalt pavement. Low temperature cracking is one of the main diseases of asphalt pavement, which is more common in northern China, especially in cold regions and areas with significant daily temperature fluctuations. Cracks will bring many accompanying diseases, such as looseness, erosion, and potholes. At present, the focus is still on considering high-temperature performance indicators, and there is still insufficient consideration for low-temperature cracking of roads in cold regions of China at the asphalt level. There are still serious deficiencies in the evaluation methods and selection of asphalt and asphalt mixtures in low-temperature areas, with a large number of modified asphalt not being evaluated. There is still a blind spot in the understanding of various influencing factors of low-temperature performance (such as type of modifier, Content of modifier, additives, etc.), resulting in problems in engineering application and higher maintenance costs in the later stage. This study mainly used BBR experiments to study different modified asphalt binders, focusing on the base asphalt and studying the influence of warm mix agents Sasobit and SNJ on the low-temperature performance and other properties of asphalt. Finally, based on the low-temperature performance of each modified asphalt, conduct an overall evaluation and comparison, and provide recommendations for the design of asphalt pavement materials.

**Keywords.** BBR test, asphalt, Sasobit, SNJ, low temperature performance

## 1. Introduction

With the increasing emphasis on environmental protection and low energy consumption in society, warm mix technology will play an important role in the application of asphalt pavement [1]. At present, warm mixing technology is mainly divided into asphalt foaming type, binder viscosity reducing type, and surface active type. This research institute uses Sasobit warm mixing agent and SNJ warm mixing agent(Chinese made adhesive warm mixing agent), both of which belong to the

[1] Fuqing YUE, Corresponding author, Transport Planning and Research Institute, Ministry of Transport, Beijing, China; E-mail: 58043619@qq.com.

adhesive viscosity reducing type. Sasobit is a long chain paraffin produced by German company Sasol Wax using FT reaction from gas. Its molecular chain is composed of 40-115 or more carbon atoms, and its melting point temperature is around 115 °C.

The paraffin components contained in Sasobit and SNJ not only reduce high-temperature viscosity [2], but also have an impact on other aspects of performance. This study will explore the effects of Sasobit and SNJ on the performance of base asphalt and SBS modified asphalt.

## 2. Experiment

### *2.1. Test Methods*

SHRP believes that the ultimate stiffness modulus S and creep rate m measured by the BBR test have a good correlation with the fracture temperature measured by the TSRST test [3], which reflects the low-temperature crack resistance performance of asphalt mixtures. Therefore, this article will use the BBR test to evaluate the low-temperature crack resistance performance of asphalt materials.

SHRP research suggests that if the stiffness S of asphalt materials is too large, they will exhibit brittleness and the road surface is prone to cracking and damage. The larger the m value of the variation rate of asphalt stiffness over time, the more shrinkage occurs when the temperature drops, and the response of the binder is like that of a material that reduces the stiffness, resulting in a decrease in tensile stress in the material and a decrease in the possibility of low-temperature cracking [4]. Therefore, in order to evaluate the low-temperature crack resistance performance of asphalt binder, it is required that the bending stiffness modulus S of the asphalt sample at the test temperature should not exceed 300MPa, and the slope m of the creep curve should not be less than 0.3. This experiment was conducted using the Canon bending beam rheometer, and the testing device and sample loading are shown in figure 1.

**Figure 1.** Bending Beam Rheometer (BBR Tester).

The evaluation criteria for asphalt after short-term aging in this study are: the bending stiffness modulus S does not exceed 200MPa, and the creep curve slope m is not less than 0.3 as the control indicators, Obtain the cracking temperature $T_{200}$ after a long service life using linear interpolation method ($T_{200}$ is equivalent to the low-temperature classification temperature of asphalt binder after RTFOT+PAV); Taking the bending stiffness modulus S not exceeding 300MPa and the creep curve slope m not less than 0.3 as the control indicators, the early cracking temperature $T_{300}$ ($T_{300}$ is the low-temperature grading temperature of asphalt binder after RTFOT) is obtained through linear interpolation method [5]. The most unfavorable cracking temperature obtained by interpolating the stiffness modulus and creep rate of two adjacent temperatures is the value of $T_{200}$ or $T_{300}$ [6].

## 2.2. Test Materials

### 2.2.1. Base Asphalt

In order to evaluate the low-temperature performance of different modified asphalt, the technical indicators of each base asphalt are shown in tables 1, 2, and 3 below.

**Table 1.** Routine Index Test Results of Esso 70 Base Asphalt.

| Test items | | Measured value | Specification requirements | Test method |
|---|---|---|---|---|
| Penetration(25℃,100g,5s),0.1mm | | 64 | 60-80 | T0604 |
| Softening point(ring and ball method),℃ | | 50.9 | ≥46 | T0606 |
| Viscosity(135℃),Pa•s | | 0.428 | / | T0625 |
| Solubility,% | | 99.8 | ≥99.5 | T0607 |
| Flash point(COC),℃ | | 276 | ≥260 | T0611 |
| Density,g/cm3 | | 1.025 | Actual measurement | T0603 |
| Ductility(5cm/min,15℃),cm | | >150 | ≥100 | T0605 |
| TFOT (163℃,5h) | Quality change,% | 0.2 | ≤0.8 | T0609 |
| | Residual penetration ratio,% | 76 | ≥61 | T0604 |
| | Ductility(15℃),cm | 57 | ≥15 | T0605 |

### 2.2.2. Preparation Method

The materials used are ESSO 70 base asphalt, Sasobit warm mix agent, and SNJ warm mix agent. The asphalt processing process is as follows: preheating the base asphalt, adding a warm mixing agent mixed with X%, and stirring for 0.5 h using an electric mixer at 165 ℃.

## 2.3. General Performance

Perform penetration test, softening point test, ductility test, and Brookfield viscosity test on the prepared asphalt, and the results are shown in table 2.

**Table 2**. Basic performance indicators of base asphalt after adding warm mix agent.

| Type of warm mixing agent | Warm mixing agent Content(%) | Penetration(25℃,0.1mm) | Softening point (℃) | Ductility(15℃, cm) | 135℃Viscosity(Pa•s) |
|---|---|---|---|---|---|
| | 0 | 64 | 50.9 | >150 | 0.428 |
| Sasobit | 2 | 52 | 56 | 56 | 0.402 |
| | 4 | 51 | 60.1 | 30 | 0.388 |
| | 0 | 64 | 50.9 | >150 | 0.428 |
| SNJ | 2 | 51 | 83.7 | >150 | 0.37 |
| | 4 | 44 | >100 | >150 | 0.312 |

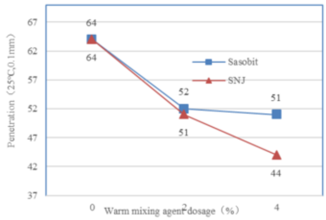


**Figure 2**. Change trend of penetration with the Content of warm mixing agent.

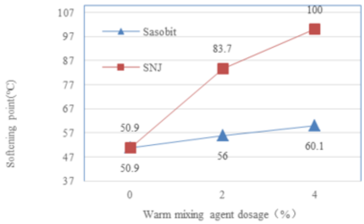


**Figure 3.** Tendency of softening point with the addition of warm mixing agent.

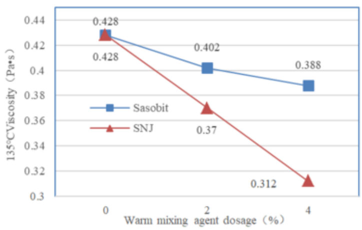


**Figure 4.** Change trend of viscosity at 135 °C with the addition of warm mixing agent.

As shown in figures 2 and 3, after adding Sasobit and SNJ warm mix agents, the penetration of asphalt decreases and decreases with the increase of the Content. At high content, the asphalt penetration decreases significantly after adding SNJ. It indicates that warm mix agents have a significant impact on the consistency of asphalt, with SNJ having a greater impact than Sasobit. After adding Sasobit and SNJ warm mix agents, the softening point of asphalt increases and increases with the increase of dosage. Among them, the increase in asphalt softening point after adding SNJ is much higher than that after adding Sasobit, and the softening point of asphalt exceeds 100 °C at a 4% SNJ content. It indicates that warm mixing agents are beneficial for improving the high-temperature performance of asphalt, with SNJ increasing more than Sasobit.

As shown in figure 4, Sasobit and SNJ have a significant effect on reducing viscosity of asphalt. With the increase of the amount of warm mix agent, the viscosity rapidly decreases, with SNJ decreasing more than Sasobit.

According to the ductility data in table 1, after adding Sasobit, the ductility value of asphalt shows a decreasing trend, and the decrease is significant; After adding SNJ, no distinctive results were found due to limitations in the experimental method. Through ductility, it can be simply explained that Sasobit will reduce the low-temperature performance of asphalt, and the impact of SNJ on the low-temperature performance of asphalt is unknown.

Given the limitations of ductility testing, it is necessary to evaluate the impact of Sasobit and SNJ on low-temperature performance through other testing methods.

## 3. BBR Test Results

After short-term aging of the prepared asphalt, low-temperature bending beam rheological test was conducted, and the test results are shown in table 3.

**Table 3**. BBR test results after adding warm mixing agent.

| Type of warm mixing agent | Warm mixing agent Content (%) | -6℃ S | -6℃ m | -12℃ S | -12℃ m | -18℃ S | -18℃ m | $T_{200}$ (℃) | $T_{300}$ (℃) |
|---|---|---|---|---|---|---|---|---|---|
| Sasobit | 0 | 67 | 0.481 | 189.5 | 0.37 | 456.5 | 0.259 | -22.2 | -24.5 |
| | 2 | 71 | 0.340 | 200 | 0.262 | 523 | 0.232 | -22.0 | -23.6 |
| | 4 | 91 | 0.413 | 259 | 0.318 | 552 | 0.215 | -19.9 | -22.8 |
| SNJ | 0 | 67 | 0.481 | 189.5 | 0.37 | 456.5 | 0.259 | -22.2 | -24.5 |
| | 2 | 105 | 0.424 | 297 | 0.326 | 540 | 0.252 | -19.0 | -22.1 |
| | 4 | 115 | 0.396 | 327 | 0.305 | 554 | 0.231 | -18.4 | -21.2 |

Note: $T_{200}$ refers to the cracking temperature of asphalt pavement after a long service life; $T_{300}$ refers to the early cracking temperature of asphalt pavement during use.

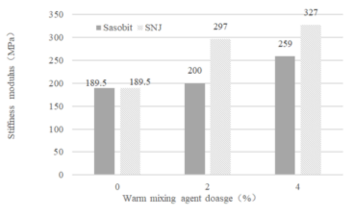


**Figure 5.** Change trend of stiffness modulus with the addition of warm mix age(-12℃).

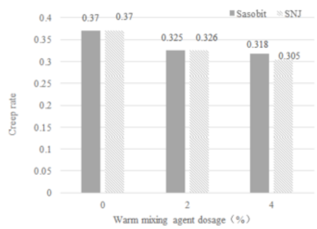


**Figure 6.** Change trend of creep rate with the Content of warm mix agent(-12℃).

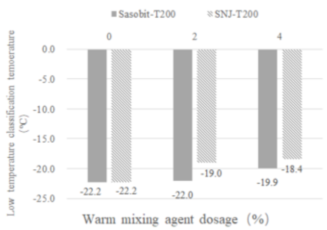


**Figure 7.** Effect of Type and Content of Warm Mixing Agent on Low Temperature Grading Temperature $T_{200}$.

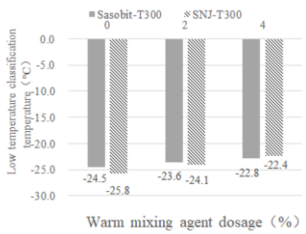


**Figure 8.** Effect of Type and Content of Warm Mixing Agent on Low Temperature Grading Temperature $T_{300}$.

According to table 3, combined with figures 5 and 6, the stiffness modulus increases with the increase of the amount of warm mix agent. The increase amplitude of the SNJ group is higher than that of the Sasobit group, and the creep rate decreases with the increase of the amount of warm mix agent.

By observing the low-temperature classification temperature shown in figure 7 and figure 8, it was found that the low-temperature classification temperature increased with the increase of the amount of warm mixing agent. Among them, the increase in low-temperature classification temperature $T_{200}$ in the SNJ group was higher than that in $T_{300}$, with an increase of 4 ℃. This indicates that warm mixing agents are detrimental to the low-temperature performance of asphalt, and SNJ is more detrimental to low-temperature performance than Sasobit. At the same time, combined with the ductility data in the previous section, the opposite reason is due to the defects of the ductility test system and the different test temperatures used in the experiment.

## 4. Conclusion

This article explores the effects of Sasobit and SNJ on base asphalt. The following conclusions are obtained:

(1) After adding Sasobit and SNJ to Esso 70 asphalt, the penetration of asphalt decreases, the softening point increases, the ductility decreases, and the 135 ℃ Brookfield viscosity decreases. The influence of SNJ is greater than that of Sasobit.

(2) Through BBR testing, it was found that warm mix agents are detrimental to the low-temperature performance of asphalt, and SNJ has a higher degree of disadvantageous effect on low-temperature performance than Sasobit.

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