Preparation and Performance Evaluation of Non-Sticky Wheel Emulsified Asphalt

Jia Wang¹,², Lu Zhang³*, Dongliang Zhang³, Huali Lu³

¹ Research and Development Center of Transport Industry of Technologies, Materials and Equipments of Highway Construction and Maintenance, Shijiazhuang 050091, China;
² Hebei Provincial Communications Planning and Design Institute, Shijiazhuang 050091, China;
³ China Construction Infrastructure Co. LTD, Beijing 100000, China
Email: 408169008@qq.com

Abstract. The existing emulsified asphalt has the defect of adhesion to construction vehicle tires, which leads to the failure of interlayer adhesion. From the softening point of improving the evaporation residue of emulsified asphalt, Non-sticky wheel emulsified asphalt was prepared with different matrix asphalt, modifier and modifier dose. Combined with the standard viscosity, storage stability and evaporation residue of emulsified asphalt, the technical properties of Non-sticky wheel emulsified asphalt were analyzed. The viscosity wheel performance of Non-sticky wheel emulsified asphalt was tested by viscosity wheel performance test. Compared with ordinary emulsified asphalt and SBR modified emulsified asphalt sold in the market, its non-stick wheel effect is significant under the condition of 60℃, which has good engineering practical application value.

Keyword: Non-sticky wheel emulsified asphalt, Sulfonated asphalt powder, Adhesion wheel performance

1. Introduction

In pavement construction, that interlayer adhesion has great influence on the pavement performance of asphalt mixture. The quality of inter-layer adhesion is one of the important factors affecting the service life of the road surface. If the inter-layer adhesion is not good, it will destroy the integrity of the road surface structure, reduce the overall resistance of the road surface structure, lead to the occurrence of road diseases, and reduce the service life of the road surface [1-2].

Emulsified asphalt is often used as the bonding agent between the surface layers, and the cohesive layer emulsified asphalt is sprayed between adjacent structure layers, so that the pavement multi-layer structure has good structural bearing capacity and durability. However, in the practical application process, after demulsification of common emulsified asphalt, the phenomenon of emulsified asphalt sticking to the wheels of construction vehicles often occurs due to the driving of engineering vehicles. The adhesive property of subsequent paving layer is reduced and the adhesive layer is ineffective. Increases the possibility of interlaminar shedding. To solve this problem, scholars have carried out a series of studies [3-8] and achieved certain results. However, the high price of modifier leads to the high cost of non-sticky wheel emulsified asphalt, and the promotion space is limited.

The author analyzed the reasons why emulsified asphalt sticks to tires: the softening point of asphalt base for producing emulsified asphalt is low, and the surface temperature can reach 60℃ in
summer. Under high temperature conditions, the oil film of emulsified asphalt becomes soft after demulsification, and the softened asphalt oil film sticks to the tires of vehicles and is taken away during the construction of engineering vehicles. This results in the failure of interlayer bonding of emulsified asphalt. Therefore, a non-sticky wheel emulsified asphalt was prepared by using hard asphalt with high softening point and additives that can improve the softening point, and the properties of non-sticky wheel emulsified asphalt were analyzed.

2. Test Section

2.1. The Raw Material

2.1.1. Asphalt. The softening point of 70# matrix asphalt is only 46℃, which cannot meet the service requirements. Therefore, 30# petroleum asphalt with higher softening point is adopted as the matrix asphalt emulsified with non-sticky wheel. According to the requirements in the asphalt test specification [9], the indicators are shown in table 1.

| Test content                     | 30# asphalt | Test method |
|----------------------------------|-------------|-------------|
| Penetration (25 ℃)/(0.1 mm)      | 26          | T0604       |
| Ductility (10 ℃)/cm              | 7           | T0605       |
| Softening point/℃                | 58.5        | T0606       |
| Density (20℃)/(g·cm⁻³)           | 1.033       | T0603       |
| Solubility/%                     | 99.9        | T0607       |
| Dynamic viscosity (60℃)/(Pa·s)   | 700         | T0620       |

2.1.2 Emulsifier. According to the technical specification for highway asphalt construction [10], the medium split cationic emulsifier is selected.

2.1.3 Modifier. The modifier is sulfonated asphalt powder. It can effectively improve the softening point of emulsified asphalt residue. Another modifier is Honeywell 7610 emulsified asphalt modifier, which can greatly improve the softening point of emulsified asphalt residue.

2.1.4 Other additives. Other additives in Non-sticky wheel emulsified asphalt are stabilizer and defoamer.

2.2. Preparation of Non-Sticky Wheel Emulsified Asphalt

The sulfonated asphalt powder can improve the high temperature performance of asphalt. The softening point of asphalt can be obviously improved by adding the sulfonated asphalt powder into the matrix asphalt. When used in combination with Honeywell 7610 high temperature modifier, the emulsified asphalt prepared can produce the effect of non-stick wheel during construction at higher temperature. The author added the sulfonated asphalt powder with mass ratio of 3%, 5%, 8% and 10% respectively as modifier of emulsified asphalt to determine the optimal amount of the sulfonated asphalt powder. Honeywell 7610 emulsified asphalt high temperature modifier price is too high, in order to control the cost, the amount of addition control is not more than 1%.

Table 2 shows the influence of different amounts of sulfonated asphalt powder on the performance of emulsified asphalt. It can be seen from the table that when the addition amount of sulfonated asphalt powder is 3%, the softening point is only 65℃, which cannot meet the technical requirements, while when the addition amount is 10%, the three indexes of residual amount on the screen, degree of injection and 1day storage stability cannot reach the technical requirements [11]. Therefore, the content of sulfonated asphalt powder is between 5% and 8%. It can be seen from the table that the
higher the content of sulfonated asphalt powder, the higher the softening point of the evaporation residue of emulsified asphalt, and the more obvious the improvement of adhesion to wheels. When the content of sulfonated asphalt powder increases from 5% to 8%, the softening point increases only by 1.5°C, indicating that the improvement effect of asphalt powder on softening point decreases gradually after the content exceeds 5%. Emulsified asphalt with the content of sulfonated asphalt powder less than 5% has good properties without apparent precipitation, agglomeration and stratification. When the content of sulfonated asphalt powder is more than 5%, a small amount of granular precipitation appears at the bottom of emulsified asphalt, which has a certain negative impact on the uniformity and storage stability of emulsified asphalt. Therefore, in combination with the production cost and technical index requirements, the author determines to use 5% of sulfonated asphalt powder as the best content of non-sticky wheel emulsified asphalt.

Table 2. Properties of emulsified asphalt with different content of sulfonated asphalt powder.

| Content sulfonated asphalt powder/% | 3% | 5% | 8% | 10% |
|------------------------------------|----|----|----|-----|
| Pass 1.18mm sieve residue content/% | <0.1 | 0.01 | 0.03 | 0.07 | 0.12 |
| Evaporation residue content/%      | >50 | 51.2 | 51.8 | 51.5 | 51.6 |
| Saybolt viscosity (25℃)            | 3-50 | 12 | 16 | 21 | 25 |
| Penetration (25 ℃)/(0.1 mm)        | 15-50 | 24 | 21 | 18 | 14 |
| Performance of residue             | >70 | 65 | 71 | 72.5 | 74 |
| Softening point/℃                  | >97.5 | 99.5 | 99.1 | 98.4 | 97.6 |
| Storage stability/%                | 1d | <1 | 0.3 | 0.3 | 0.6 | 1.2 |
|                                   | 5d | <5 | 1.1 | 1.5 | 2.0 | 2.6 |

2.3. Preparation Process of Non-Sticky Wheel Emulsified Asphalt

The process flow of non-sticky wheel emulsified asphalt is shown in figure 1. Emulsifier, stabilizer, defoamer and water were mixed in proportion according to the formula to make emulsifier solution, which was heated to 70-80℃. 30# asphalt was preheated to 170-180℃, then sulfonated asphalt powder was added and mixed evenly. The colloidal mill was preheated to 80℃, the emulsifier solution was poured into the colloidal mill, and the high temperature asphalt was slowly poured into the emulsion. After the asphalt is added, grind it until the emulsified asphalt is evenly mixed, the solution is fine and granular, shut down the mill and release the emulsified asphalt. After the emulsified asphalt is released, it is cooled to below 50℃ and sealed for preservation. The finished product is non-sticky wheel emulsified asphalt.

Figure 1. Preparation process of Non-sticky wheel emulsified asphalt.
3. Performance Analysis of Non-Sticky Wheel Emulsified Asphalt

3.1. Physical and Chemical Properties
The physicochemical properties of non-sticky wheel emulsified asphalt prepared according to the above process and formula are shown in Table 3. The comparison test uses 70# matrix asphalt to prepare common emulsified asphalt and SBR modified emulsified asphalt sold in the market. It can be seen from the table that the softening point of non-sticky wheel emulsified asphalt reaches 72°C, which is much higher than that of ordinary emulsified asphalt and SBR modified emulsified asphalt, while the penetration degree is significantly lower than that of these two emulsified asphalt. This indicates that the high temperature performance of non-sticky wheel emulsified asphalt is significantly better than the other two kinds of emulsified asphalt, which can prevent the adhesion during the wheel rolling process, and the asphalt layer is not easy to be taken away by construction vehicles. The viscosity, storage stability and other indexes of non-stick wheel emulsified asphalt have little difference with the other two emulsified asphalt, which improved the high temperature performance and maintained the stability of other physical and chemical indexes.

| Technical indicators          | Non-sticky wheel emulsified asphalt | Ordinary emulsified asphalt | SBR modified emulsified asphalt |
|------------------------------|------------------------------------|----------------------------|--------------------------------|
| Pass 1.18mm sieve residue content [%] | 0                                  | 0                          | 0                              |
| Evaporation residue content [%] | 51.6                               | 51.5                       | 51.8                           |
| Saybolt viscosity (25°C)      | 12.5                               | 7.4                        | 9.7                            |
| Penetration (25 °C)/(0.1 mm)  | 18                                 | 65                         | 71                             |
| Softening point/°C            | 72                                 | 46                         | 52                             |
| Solubility/%                  | >99.0                              | 99.5                       | 99.1                           |
| Storage stability [%]         | 1d                                 | 0.3                        | 0.2                            |
|                              | 5d                                 | 1.8                        | 2.2                            | 1.9                            |

3.2. The Control Index of Sticking Wheel
The performance of non-sticky wheel emulsified asphalt is tested by simulating the road surface rolling process of automobile tires. The specific method is as follows: apply non-sticky wheel emulsified asphalt uniformly on a rutting plate surface according to the sprinkling amount of 400g/m² [12]. After it is completely demulsified, it should be placed in a rut tester at 60°C. The rolling times of the roller of the rutting tester on the surface of the rutting board were set as 10-20 times. Then, a piece of white paper is spread on the rutting board to be rolled twice to observe the adhesion degree of the white paper to the asphalt on the tire, so as to indirectly judge the adhesion effect of non-adhesion wheel emulsified asphalt. The comparison test uses the common emulsified asphalt and the SBR modified emulsified asphalt sold in the market. The same sprinkling amount and the same test method were used for coating and rolling. The comparison results are shown in figure 2.

As can be seen from the figure, specimens coated with ordinary emulsified asphalt and SBR-modified asphalt have a large amount of asphalt attached to the white paper. On the other hand, the test specimen coated with non-sticky wheel emulsified asphalt have little asphalt adhesion to the white paper and only slight roll imprint. It shows that the tyre surface can still be kept from adhering to asphalt under the condition of 60°C, and non-sticky wheel emulsified asphalt is the best effect.
(a) SBR modified emulsified asphalt; (b) Ordinary emulsified asphalt; (c) Non-sticky wheel emulsified asphalt.

**Figure 2.** Comparison of properties of different emulsified asphalt adhesion to wheels.

By weighing the weight of the white paper before and after the tire rolling, the mass change of adhesive asphalt on the white paper can be obtained, and the corresponding adhesion rate of emulsified asphalt on the tire can be calculated, so as to quantitatively evaluate the adhesion of non-sticky wheel emulsified asphalt. The calculation formula is shown in follow formula [13].

\[
\eta = \frac{m_2 - m_1}{s \times a}
\]

In the formula:

- \(\eta\): the adhesion rate;
- \(m_2\): quality of white paper after test (g);
- \(m_1\): Quality of white paper before test (g);
- \(s\): Wheel track walking area (m\(^2\));
- \(a\): Sprinkling quantity (g/m\(^2\)).

The wheel track walking area is calculated according to the actual measurement, which is 5cm×25cm; The sprinkling quantity is 400g/m\(^2\).

The calculation results are shown in table 4. It can be seen from the table that the adhesion rate of ordinary emulsified asphalt reaches above 30%, which indicates that in practical application, after the ordinary emulsified asphalt is scattered, a large number of emulsified asphalt will be attached to the tire in the subsequent construction process, making the emulsified asphalt lose the bonding effect. The adhesion rate of SBR modified emulsified asphalt is 17%, and a large amount of emulsified asphalt will be taken away by wheels. The adhesion rate of non-sticky wheel emulsified asphalt is only 1.3%, almost no asphalt adhesion to the wheel surface. In practical application, the wheel rolling has little influence on the emulsified asphalt layer. Emulsified asphalt can play its bonding role.

**Table 4. Adhesion rates of different emulsified asphalt.**

| Types of emulsified asphalt       | Quality of adhesive asphalt (g) | Adhesion rate (%) |
|----------------------------------|-------------------------------|------------------|
| SBR modified emulsified asphalt  | 0.854                         | 17.12            |
| Ordinary emulsified asphalt      | 1.688                         | 33.76            |
| Non-sticky wheel emulsified asphalt | 0.066                     | 1.32             |

Through the adhesive wheel test designed by the author, the rolling and adhesion of the wheels to emulsified asphalt in actual construction were simulated. The experimental results show that the
adhesion rate of non-sticky wheel emulsified asphalt is significantly lower than that of ordinary emulsified asphalt and SBR modified emulsified asphalt sold in the market under the condition of 60℃, and the non-sticky wheel effect is significant. It has good engineering practical application value.

4. Conclusion
1. Using 30# hard asphalt instead of ordinary petroleum asphalt, using sulfonated asphalt powder and Honeywell 7610 modifier to further improve the softening point of emulsified asphalt residue, so that emulsified asphalt has the effect of not adhering to wheels. At higher temperatures, emulsified asphalt shows better high temperature resistance and non-sticky wheel performance. When the content of sulfonated asphalt powder is 5% and that of Honeywell 7610 is 1%, it is the best mixture.
2. The performance indexes of non-sticky wheel emulsified asphalt meet the requirements of the specifications, and the softening point is much higher than that of ordinary emulsified asphalt and SBR modified emulsified asphalt. Its adhesion rate is greatly reduced at different temperatures, which has good practical application value in engineering.

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