Experimental Analysis on Road use of Plant Asphalt

Yan Jingchen, Shen Li

(Inner Mongolia University of Technology Civil engineering Institute, Hohhot 010051)

Abstract: With the rapid development of transportation industry, highway construction in China is advancing by leaps and bounds, and the demand for pavement materials is also increasing. With the depletion of petroleum resources, the price of petroleum asphalt, which is widely used in pavement, is rising, and it is not easy to degrade petroleum asphalt, so the utilization ratio of waste asphalt is low and the environment is polluted. Therefore, it is necessary to seek some substitute or a kind of renewable environmental protection asphalt, and the large-scale production of vegetable asphalt provides a new way for it. In this paper, plant asphalt is mixed with 90 base asphalt in different proportion (0%, 10% and 15%), and the mixture asphalt is determined. To explore the effect of plant asphalt on the three indexes, temperature sensitivity and ageing performance of base asphalt.

1. Overview
Plant asphalt is mainly derived from the downstream products of phytochemical alcohols, that is, wastes extracted from plant oil from plant stalks, which are not polyaromatic complex compounds and are mainly composed of fatty acids and plant alcohols, so they have low carbon and environmental protection. Renewable advantages. At the same time, the price of plant asphalt is much cheaper than that of petroleum asphalt. If the plant asphalt is mixed with matrix asphalt, it can not only reduce the cost of road construction, but also reduce the pollution caused by the burning of plant straw.

2. General situation of test
This paper intends to heat up both No. 90 base asphalt and plant asphalt to 135 °C, and pour the plant asphalt of different required mass ratio into 90 base asphalt in different proportion (0 5% 10% and 15%) into the base asphalt to carry out a comparative study. In order to determine the effect of plant asphalt on the performance of asphalt matrix. The plant asphalt produced by Changchun Dacheng Group and the base asphalt produced by PetroChina Liaohe Petrochemical Company are selected. The technical index of plant bitumen is shown in Table 1 as follows:

| Test item               | Test method; | Reference requirements | Result |
|------------------------|--------------|------------------------|--------|
| Kinetic viscosity (60°C), (Pa • s) | T0620        | ≥350                   | 543    |
| Flashpoint (°C)        | T0611        | ≥230                   | >230   |
| Volatility (163°C,3h)(%) | -            | ≤1                     | ≤1     |
| Density (25°C),(g/cm)  | T0603        | 1.200-1.300            | 1.268  |
3. The three index of asphalt

The three indexes of asphalt refer to the penetration, softening point and ductility of asphalt. They are not only the three primary indexes in the grading of penetration degree, but also the important indexes for the production and construction enterprises to measure the quality of asphalt. The penetration, softening point and ductility of five kinds of bitumen (plant asphalt accounts for 0% 5% 10% 15% 20% of total bitumen) have been studied. The temperature of penetration and ductility are 5 ℃ 10 ℃ and 25 ℃, respectively. The results are shown in table 2 below:

| Test item       | Temperature (℃) | NO.90 | 5% blending | 10% blending | 15% blending | 20% blending |
|-----------------|-----------------|-------|-------------|--------------|--------------|--------------|
| Penetration (0.1mm) | 5              | 13.7  | 14.7        | 17.2         | 21.7         | 23.2         |
|                 | 10              | 21.5  | 22.2        | 24.3         | 29.6         | 31.2         |
|                 | 25              | 84.8  | 86.5        | 89.1         | 91.1         | 96.8         |
| Ductility (mm)  | 5               | 105   | 124         | 153          | 156          | 142          |
|                 | 10              | 308   | 268         | 254          | 223          | 199          |
|                 | 25              | >1000 | >1000       | >1000        | >1000        | >1000        |
| Softening point (℃) | 51.7           | 52.3  | 52.9        | 54.1         | 53.5         |

![Graphs showing asphalt penetration and ductility](image)

Fig.1
From Table 2 and figure 1 above, the following conclusions can be obtained: first, with the increasing of the blending amount of vegetable asphalt, the penetration of mixed asphalt increases gradually at 5 °C or 25 °C. The blending of vegetable asphalt improves the low temperature performance of base asphalt. At the same time, the softening point of asphalt increases, but when the content reaches 15%, the index will be reduced. Within 15% of the content, the blending of vegetable asphalt can improve the high temperature performance of the 90th base asphalt. The ductility of mixed asphalt decreases gradually with the addition of plant asphalt at 10 °C, but when the temperature drops to 5 °C, the blending amount of mixed asphalt in plant asphalt is less than 15%. The delay degree increases gradually with the increase of plant asphalt content, but when the content increases to 20, the low temperature ductility decreases. This indicates that the low temperature cracking resistance of mixed asphalt is improved when the content of vegetable asphalt is not more than 15%, but the performance of adding vegetable asphalt will be decreased.

4. Ageing resistance

RTFOT method and PAV method were used to evaluate the ageing of asphalt during mixing and spreading, as well as the long-term external environmental factors affecting the ageing. Two kinds of ageing bitumen samples are generally used. Mass loss evaluation of its ageing performance, because some materials in the asphalt oxidation reaction, resulting in an increase in the total weight of asphalt, so the weight loss is not accurate. The ageing performance of asphalt was evaluated. The ageing resistance of asphalt mixture was evaluated. The asphalt permeability (PRR) and softening point increment (SPI) were used to evaluate the ageing performance of asphalt.

4.1 Penetration Retention Rate

Residual penetration ratio calculation formula is shown in the following formula 1:

\[
PRR(\%) = \frac{P}{P_0} \times 100\% 
\]  

(1)

Type: \(P_0\) — Penetration before ageing asphalt(0.1mm).

\(P\) — Penetration after ageing asphalt(0.1mm).

Generally believed that the penetration retention rate is smaller, the worse performance of asphalt ageing. In this study, the influence ageing on the penetration under 25 °C as shown in Table 3:

| Penetration (25 °C) | Plants asphalt content (percentage of the total mass) |
|---------------------|-----------------------------------------------|
|                     | NO.90 5% blending | 10% blending | 15% blending | 20% blending |
| Original asphalt    | 8.48 8.65         | 8.91         | 9.11         | 9.68         |
| RTFOT (mm)          | 5.22 5.33         | 5.51         | 5.83         | 6.26         |
| RTFOT PRR           | 61.6% 61.7%       | 61.9%        | 64.0%        | 64.7%        |
| RTFOT+PAV (mm)      | 2.04 2.39         | 2.77         | 2.91         | 3.41         |
| RTFOT+PAV PRR       | 24.1% 27.6%       | 31.1%        | 31.9%        | 35.2%        |
According to Table 3 and figure 2, we can draw the following conclusion: the compactness of asphalt mixture at 25 °C, whether initial, short-term or long-term, increases with the increase of mixing strength. By casting plant asphalt, the low temperature performance of asphalt is improved effectively. At the same time the residual penetration rate of asphalt mixture at 25 °C also increases with the increase of the amount of plant asphalt added at which effectively improves the anti-ageing performance of plant asphalt.

4.2 Softening Point Increment

Softening point increment calculation formula is shown in the following formula 2:

\[ \text{SPI}(\degree \text{C}) = \text{SP} - \text{SP}_0 \]  (2)

Type: \( \text{SP}_0 \) — Softening point before ageing \( (\degree \text{C}) \).

\( \text{SP} \) — Softening point after ageing \( (\degree \text{C}) \).

Generally believed that the softening point increment, the worse performance of asphalt ageing. In this study, the influence ageing on softening point the as shown in Table 4:

| Softening point \( (\degree \text{C}) \) | Plants asphalt content (percentage of the total mass) |
|-----------------------------------------|-----------------------------------------------------|
|                                        | NO.90 | 5% blending | 10% blending | 15% blending | 20% blending |
| Original asphalt                        | 51.7  | 52.3        | 52.9        | 54.1        | 53.5         |
| RTFOT                                   | 58.3  | 60.6        | 60.0        | 59.0        | 59.7         |
| PAV+RTFOT                               | 63.9  | 64.9        | 66.1        | 67.3        | 66.6         |
| RTFOT SPI                               | 6.6   | 8.35        | 7.15        | 4.95        | 6.2          |
| PAV+RTFOT SPI                           | 12.2  | 12.6        | 13.25       | 13.2        | 13.1         |
According to Table 5 and figure 3, we can draw the following conclusions: on the one hand, the softening point of the original ageing asphalt and the long-term ageing asphalt shows an upward trend at the same lifting level, thus increasing the softening point of the asphalt. With the increase of plant asphalt content and the increase of asphalt content, the tempering performance of plant asphalt is improved effectively when the content of plant asphalt is increased by more than 15%. The temperature is stable within 15% of the blending amount. On the other hand, with the increase of the content of plant asphalt, the SPI of short term ageing asphalt decreases, and the performance of plant asphalt is improved effectively. Using SPI to evaluate the Ageing Resistance of Asphalt The long-term ageing resistance of asphalt 90 is not obviously improved, but the long-term ageing resistance of asphalt is not improved obviously.

5. Conclusion
1. Asphalt mixture can effectively reduce the temperature sensitivity of asphalt 90, and the best effect is when the content of asphalt reaches 10.
2. Plant asphalt can effectively improve the high temperature stability and low temperature crack resistance of asphalt 90.
3. Plant asphalt can effectively improve the anti-ageing performance of asphalt 90, but the effect of long-term and short-term ageing is different, the content of both is increased in the range of 10%.

References:
[1] Zhou Nanyang, GE Lan, Zhou Yuhong, et al. Application of vegetable Asphalt in Road Construction Technology [J]. East China Highway 1: 62-65.
[2] Tan Yiqiu, Jiang Liwei, Zhu Haoran. Sensitivity Analysis of Three Temperature Penetration Degrees for Evaluating Temperature Sensitivity of Asphalt [J]. Northeast Highway, 2001,1:25-28.
[3] Shen Jinan. Equivalent softening point and equivalent brittle point index of road asphalt [J]. Highway traffic technology 1997 1: 46-52.
[4] Jin Ze, Zhao Chaohui, Wei Yi, et al. Comparison of Ageing Resistance of two kinds of Road Asphalt [J]. Journal of the University of Petroleum and Chemical Engineering / 2002 / 12: 5-10.
[5] Zhang Zhengqi, Liang Xiaoli. Evaluation method of Asphalt Ageing property [J]. Journal of Communications and Transport Engineering .2005.3: 13-17.
[6] Li Ning Li, Zhang Cai-li, Xiao Qingyi, et al. Evaluation index of asphalt ageing resistance [J]. Journal of Hebei University of Technology.