The Research on Aging Performance of Rubber Asphalt Based on Laboratory Test

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Abstract. Gansu province has complex topography, strong ultraviolet radiation, so the asphalt pavement often appears aging and other diseases in the service period. Firstly, the rubber asphalt for as short-term and long-term were made to be the simulated aging test by the Asphalt rotary film heating test (RTFOT) and the pressure ageing vessel (PAV) accelerated asphalt aging test. Secondly, the rubber asphalt was studied by the UV aging; the RTFOT aged sample was placed to be the ultraviolet aging in ultraviolet radiation box to do the Dynamic shear test (called DSR). The results showed that: the rubber asphalt had better ability to resist fatigue and anti-ultraviolet ageing, suitable for high altitude strong ultraviolet region in Gansu province.

1. Introduction

Gansu Province is located in west in China, which has low annual average temperature, different daily temperature, low pressure, strong ultraviolet radiation, clear dry and wet season, more fixed freeze-thaw cycle etc.; these characteristics will have adverse effects for road asphalt pavement, so the area of the road has more cracks, deformation, loose and aging and other diseases. The asphalt as an organic material is easy to produce temperature shrinkage cracks at winter because of the suddenly cooled weather, coupled with repeated changes in temperature; rain and other water easily penetrate the road to result in decreased asphalt adhesion with the rainy season approaching; Pedestrian and other loads will cause the road to produce stripping, rutting, pit and other diseases, seriously affecting the normal use of asphalt pavement function and shortening the service life [1]. Numerous references show that [2-4]: the application of rubber asphalt in China is growing due to its good road performance. However, the phenomenon of thermal oxygen aging exists in the whole process of its use from the initial preparation of cemented material, the pouring construction and compaction of site mixture to the pavement completed. The asphalt aging evaluation system is usually TFOT or RTFOT for the short-term aging in the specification and PAV for the long-term aging as the main evaluation method in the current application situation, but the UV aging (UV aging) is not considered [5-6]. Asphalt pavement has aging phenomenon in fact since its application. The current evaluation methods and evaluation indicators are mainly for the phenomenon of thermal oxygen aging, not for the evaluation of UV light aging phenomenon [5-8]. And the aging of rubber asphalt binder in construction process may be more serious than that of ordinary asphalt mixture, so the study of anti-ultraviolet aging performance of rubber asphalt is very necessary. Domestic and foreign experts or scholars have done a lot of work on the short and long-term aging of asphalt in the past studies, while...
the research on the aging of the asphalt pavement in high altitude areas is relatively scarce. Therefore, the performance of rubber asphalt would be studied among the short-term, long-term and under different conditions of UV aging in this article.

2. Test overview

2.1. A Test raw materials

Rubber asphalt: the Asphalt used in this test was made by the SK 90 asphalt, 20% of the mixed waste tire powder, at 190 °C reaction temperature, 60min reaction time and high-speed mixing conditions. The performance indicators met the Gansu weather conditions on the rubber asphalt technical standards (seen in Table 1).

| Items                | Cold area | Warm area | Hot area | Results of testing |
|----------------------|-----------|-----------|----------|--------------------|
| 180°C Rotational viscosity/Pa·s | 1.0 ~ 3.0 | 2.0 ~ 4.0 | 2.5 ~ 5.0 | 2.2                |
| 25°C Penetration/mm   | >50       | >58       | >65      | 72.5               |
| Soften point/°C       | <50       | <55       | <60      | 66.0               |
| Recovery of elasticity/% | >10      | >10       | >5       | 12.8               |
| 5°C Ductility/cm      |           |           |          |                    |

2.2. Testing program

The blank rubber asphalt was used to accelerate the asphalt aging test simulates short-term aging and long-term aging by the asphalt film oven heating test (RTFOT) and the pressure aging tank (PAV) from [6]. As the rubber asphalt mixture construction temperature was generally above 160 °C, and rubber asphalt would also produce swelling phenomenon in the short-term aging, so the RTFOT test temperature was 183 °C, rather than the standard short-term aging temperature; the rubber asphalt PAV would be made at aging temperature of 110 °C, pressure of 2.1MPa, and reaction time of 20 h. The SHRP performance test was made for the prepared original asphalt, RTFOT aging rubber asphalt and PAV aging rubber asphalt after the RTFOT aging at different temperature conditions; the effects of different temperatures on the aging properties of rubber asphalt were compared.

The UV aging of rubber asphalt was studied. Test set [9]: firstly, six test pieces were prepared with a diameter of 140 mm and a height of 10 mm; secondly, each sample plate was weighed about 50 g of rubber asphalt and placed in an environment of 183 °C for RTFOT aging and the RTFOT aged Thickness of about 1 mm controlled; the samples after the aging of RTFOT were placed in the ultraviolet radiation box for UV aging (sample daily radiation 16h, interval 8h); the UV radiation box temperature was controlled below 40 °C in order to avoid the asphalt sample thermal aging; the samples were subjected to DSR testing.

3. The Short - term and Long - term Oxidation Aging results analysis of Rubber

The aging of RTFOT (aging temperature of 183 °C) and aging of PAF after RTFOT were simulated the short-term aging and long-term aging performance in this paper in order to prevent short-term aging and long-term aging of rubber asphalt during the production and service cycle. The dynamic shear rheological tests were made at 52 °C, 58 °C, 64 °C, 70 °C, 76 °C, 82 °C and 88 °C. The results are shown in Table 2.

| Samples | DSR Rheological parameters | Test temperature(T/°C) |
|---------|----------------------------|------------------------|
| Blank   | δ                          | 52 | 58 | 64 | 70 | 76 | 82 | 88 |
|         | 63.7                       | 66.0 | 69.1 | 72.3 | 75.0 | 78.9 | 78.9 |
Table 2 showed: the δ after aging of RTFOT was smaller than that of blank rubber asphalt under different test conditions; and the δ decreases, indicating that the elasticity part of rubber asphalt was increased and the corresponding viscosity component was reduced; to a certain extent, the ability to resist shear deformation was strengthened; the phase angle of PAV aging before 64 ℃ was greater than that of the RTFOT samples, smaller after 64 ℃, and the phase angle of RTFOT samples was higher than that of the PAV samples. The internal elastic components after PAV aging were less than that of the RTFOT samples, the viscous part enhanced, resistance to shear deformation decreased (i.e., rutting resistance weakened) below 64 ℃; the internal elastic component after PAV aging were more than that of the RTFOT samples, the viscosity part reduced, resistance to shear deformation capacity increased (i.e., rutting resistance enhancement) higher than 64 ℃. The PAV aging rutting factor was the largest, RTFPT second, and the blank rubber asphalt smallest. This also reflected: the rubber asphalt had a good load response capability, a lower phase angle at high temperature and low frequency (10 rad/s), showing better resistance to rutting. But the overall trend of rubber asphalt before and after aging was basically the same with the temperature changing, and the variation range was not big, which proved that the rubber asphalt could be used in high altitude area and had excellent anti-fatigue aging ability.

4. The Anti-UV Aging Results Analysis of Rubber

4.1. A Experimental method

The samples after RTFOT aging were placed in an ultraviolet radiation box for 1 month, 3 months, 6 months, 9 months, 12 months and 15 months of UV aging test, and tested the DSR results for different UV aging samples. Gansu Province has more complex, which Gannan climate characteristics have significantly higher altitude, strong ultraviolet characteristics, so the Gannan area is chosen to be the experimental study area. The annual average solar elevation angle range is between 30° and 40° according to the annual average solar height angle formula—h = π / 4 (90° - φ), and it is deduced that the solar ultraviolet radiation in this area is 7% of the total radiation. The average annual solar radiation in the area is between 4430 MJ and 5499 MJ per square meter according to the relevant literatures, and the distribution of ultraviolet radiation is 310 MJ ~ 385 MJ per square meter. If the total amount of indoor radiation is 1.1 times of the outdoor, the indoor ultraviolet radiation total range is 341 MJ ~ 423 MJ per square meter, and finally the sun ultraviolet radiation time can be calculated according to the formula Q purple = p× t, Where the parameter p represents the UV radiation intensity of the UV aging instrument and the parameter t represents the radiation time.

4.2. Results analysis

The DSR test was carried out for the blank and simulated ultraviolet radiation aging rubber asphalt samples for 1 month, 3 months, 6 months, 9 months, 12 months and 15 months respectively. The results were shown in Table 3.

Table 3. The DSR test results for different UV aging samples.

| Samples        | Test temperature (℃) | DSR Rheological parameters | RTFOT | PAV |
|----------------|----------------------|----------------------------|-------|-----|
|                | 52                   | 58                         | 64    | 70  |
| Blank rubber   | 63.7                 | 66.0                       | 69.1  | 72.3|
| rubber asphalt | 15890.0              | 8981.1                     | 5097.2| 2891.3|
|                | 76                   | 82                         | 75.0  | 78.9|
|                |                      |                            | 78.9  | 78.9|
|                | 70                   |                            | 1017.3| 1017.3|
|                | 76                   |                            | 1717.2| 1717.2|
|                | 82                   |                            | 2891.3| 2891.3|
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|                | 88                   |                            | 5097.2| 5097.2|
Table 3 showed: the ultraviolet radiation had a certain influence on the performance of rubber asphalt. The rutting factor $G^*/\sin\delta$ decreased gradually with the increase of test temperature; the rutting factor $G^*/\sin\delta$ was gradually increasing and the cementing material was hardened with the increase of UV aging time; the rubber asphalt binder performance changed the most at UV1, much larger at UV1~UV6, and slowed, stabilized after 6 months UV6. By comparing with the PAV aging data in Table 2, the phase angle $\delta$ of the rubber asphalt with 15 months of UV aging is smaller than that of samples after the aging of PAV, indicating that the internal elastic component of the rubber asphalt was enhanced and the viscous part weakened, anti-rutting performance enhanced, reflecting the aging of the UV15months of rubber asphalt UV15 performance than PAV aging performance.

### 5. Conclusions

The phase angle $\delta$ after aging of RTFOT was smaller than that of the blank rubber asphalt, and the phase angle after PAV aging was larger than that of RTFOT before 64 °C, and smaller than that of RTFOT after 64 °C. Corresponding to the PAV aging, the rutting factor was the largest, followed by RTFPT, the smallest of the blank rubber asphalt. The rubber asphalt had a lower phase angle under high temperature and low frequency (10rad/s), showing better resistance to rutting. The performance trend of rubber asphalt before and after aging is basically the same under different temperature conditions; the change range was not big, which once again proved that the rubber asphalt could be used for high altitude areas and had excellent anti-fatigue aging ability.

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### 6. Sources of project funds

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