Application of Waste Rubber Powder/SBS Double Compound Modified Asphalt in Xining South Beltway

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Abstract. Through the application of waste rubber powder/SBS double composite modified asphalt in Xining South Beltway, its superior road performance and construction feasibility have been verified. The road test results show that: The rutting stability of waste rubber powder/SBS double composite modified asphalt mixture reached 7800 times/mm, far exceeding the requirement of more than 3000 times/mm. The water stability and low-temperature bending performance also met the requirements of the index.

Introduction

All the expressways built in the early period China have entered the stage of reconstruction and expansion and major repair. According to relevant statistics, about 2,000 ~ 3000km of overlaying in the expressways need to be overhauled every year. Extending the service life of road pavements, improving and improving the performance of road pavements, and at the same time seeking overlay with good economic performance and old road reconstruction schemes, and saving construction funds, are important issues currently facing China's highway industry. There are various shortcomings in the performance of petroleum refining asphalt, so polymer-modified asphalt has been studied at home and abroad in recent years. SBR, SBS and other modified asphalt have played a good role in improving the performance of asphalt and asphalt mixture, and their modification technology is relatively mature, but due to the complexity of traffic load and environmental conditions in China and the high cost of modified asphalt, the promotion and application of polymer modified asphalt is severely limited.

Synthetic rubber, natural rubber, carbon black, metal oxides and antioxidants and other materials constitute the main components of waste tires, and these materials have a great help to improve the performance of asphalt. At present, China's rubber powder processing is industrialized, and the price of rubber powder is far lower than SBR, PE, and SBS modifiers, which has a large cost advantage. Mixing rubber powder with SBS modifier and modifying asphalt at the same time will undoubtedly take into account performance and cost advantages.

Project Overview

Located in the urban area of xining, qinghai province, the construction project of the south beltway of xining is an important part of the national expressway network, the beijing-lhasa expressway (G6) and the qinghai expressway network, as well as one of the key construction projects of the 12th five-year plan of qinghai province. Xining city is located in arid and cold area, with low temperature in summer, long cold in winter and strong solar radiation, so the laying of asphalt pavement in this area should consider the geographical environment of this area. According to the investigation and statistics of the asphalt pavement diseases in xining city and the surrounding areas, it is found that although the traffic volume in this area is not very large, the crack diseases are the most prominent. The survey results show that more than one-third of crack damage is caused by insufficient low-temperature crack resistance of asphalt mixtures. This disease has become one of the most important diseases in arid and cold regions such as Xining. If such diseases are not treated in time, cracks will develop further, causing premature damage to the base layer, which in turn
affects the surface layer, forming a vicious circle and greatly affecting the operation of roads in arid and alpine regions. Therefore, the improvement of asphalt and asphalt mixture performance, especially in low temperature performance, has a significant influence on improving the crack disease of asphalt pavement in such high and cold areas as Xining. The test section of waste rubber powder/SBS double composite modified asphalt is located on the upper layer of the south ring expressway of Xining, with a single length of about 500m. The pavement thickness of the test section is the same as that of the original pavement design. From bottom to top, the original asphalt pavement structure is: 20cm thick cement stabilized soil (gravel) subbase; 38cm thick cement stabilized soil (gravel) base and 40cm thick cement stabilized soil (gravel) base; prime coat; seal coat; bond layer; 12cm ATB-30 bituminous macadam base course; 6cm AC-20 medium grain asphalt concrete; 6cm AC-20 medium grain modified asphalt concrete; 3cm AC-13 fine-grained modified asphalt concrete.

**Test Result of Raw Material Performance Index**

The test results of waste rubber powder/SBS composite modified asphalt and raw materials used in the test section are shown in table 1 ~ table 4.

| Test items       | unit        | technical standard | Test results |
|------------------|-------------|--------------------|--------------|
| Penetration      | 25℃ [0.1mm]| ≥55                | 57           |
| Softening point  | °C          | ≥65                | 68           |
| Ductility        | 5℃[cm]     | ≥20                | 25           |
| Viscosity        | 180°C[Pa.s]| 1.0-4.0            | 2.1          |
| Elastic recovery | 25℃[%]     | ≥70                | 79           |
| Density          | 15℃ [g/cm3]| 1.0-1.1            | 1.037        |
| RTFOT (163℃)     | Mass loss  | %[g]               | ≤0.3         | 0.1          |
|                  | Penetration ratio | %[℃]   | ≥85          | 89           |
|                  | Ductility ratio | %[℃]   | ≥80          | 97           |

| Test items                        | unit        | Fine aggregate | Specification |
|-----------------------------------|-------------|----------------|---------------|
| Apparent density                  | [ g/cm3]    | 2.813          | ≥2.5          |
| Washing method <0.075mm particle content | [%]    | 9.7            | —             |
| Sand equivalent                   | [%]        | 75             | ≥70           |

| Test items                        | unit        | Coarse aggregate | Specification |
|-----------------------------------|-------------|------------------|---------------|
| crushing value                    | [%]        | 14.5             | ≤20           |
| Loss of Wear Loss                 | [%]        | 14.6             | ≤28           |
| Relative gross volume density     | [ g/cm3]   | 10mm~16mm: 2.813 5mm~10mm: 2.815 3mm~5mm: 2.781 | ≥2.60 |
| Water absorption                  | [%]        | 10mm~16mm: 0.68 5mm~10mm: 0.9 3mm~5mm: 0.78 | ≤2 |
| Adhesion                          | [level]    | 5                | ≥5            |
| flat-elongated particles          | [%]        | 10mm~16mm: 4.1 5mm~10mm: 4.7 | ≤10 |
Washing method <0.075mm particle content [%] 10mm~16mm: 0.8 5mm~10mm: 0.5 3mm~5mm: 0.8 ≤1

Table 4. Test results of mineral powder index.

| Test items        | unit | Mineral powder | Specification |
|-------------------|------|----------------|---------------|
| Apparent density  | [g/cm³] | 2.796         | ≥2.50         |
| Water content     | [%]  | 0.4           | ≤1.0          |
| Granularity range | [ %] | 100           | 100           |
| <0.6mm            |      | 100           | 90~100        |
| <0.15mm           |      | 90~100        |               |
| <0.075mm          |      | 75~100        |               |

It can be seen from Tables 1 to 4 that the main indexes of raw materials used in the test roads are in compliance with the relevant technical requirements.

Design Proposal for Asphalt Mixture Production

Mix Proposal Design

According to the raw material reserve of the test section, the material ratio of the test road is shown in Table 5, the asphalt mixture grading is shown in Table 6, and the mixture gradation curve is shown in Figure 1.

Table 5. Production mix ratio of test road.

| Material name | Asphalt                        | 10~16mm | 5~10mm | 3~5mm | machined sand | Mineral powder | Cement |
|---------------|--------------------------------|---------|--------|-------|---------------|----------------|--------|
| standard      | composite modified asphalt     | 1# silo | 2# silo| 3# silo| 4# silo       |                 |        |
| weight        | Best asphalt-aggregate ratio 6.0| 31      | 35     | 6     | 21            | 5              | 2      |

Table 6. Grading of asphalt mixture on test road.

| Name            | Mass percentage [%] passing through the following sieve holes [mm] |
|-----------------|---------------------------------------------------------------|
| Grading cap     | 16.0 13.2 9.5 4.75 2.36 1.18 0.6 0.3 0.15 0.075             |
| 100 100 71 35 28 23 19 15 12 8                          |
| Lower grading limit | 100 95 62 25 20 15 12 10 8 4                   |
| 100.0 97.5 66.5 30.0 24.0 19.0 15.5 12.5 10.0 6.0       |
| Median grading  | 100.0 95.5 70.3 33.2 24.1 17.2 11.3 9.4 7.9 6.0         |
| Synthetic gradation | 100.0 95.5 70.3 33.2 24.1 17.2 11.3 9.4 7.9 6.0     |
Waste Rubber Powder/SBS Double Compound Modified Asphalt Mixture ARC-13 Road Performance Verification

Using the above raw materials, under the optimal oil-stone ratio, the waste rubber powder / SBS double-composite modified asphalt mixture is produced. The performance index of asphalt mixture is shown in Table 7.

![Figure 1. ARC-13 asphalt mixture gradation curve of test road.](image)

| Table 7. Test results of road performance indicators of composite modified asphalt mixture in test section. |
|--------------------------------------------------------|
| **Index test project** | **Best asphalt-aggregate ratio** | **Porosity** | **Residual stability of Marshall** | **Dynamic stability of rutting** | **Strength ratio of freeze-thaw splitting** | **Low temperature bending strain** |
| **unit** | [\%] | [\%] | [KN] | [times/mm] | [%] |          |
| **specification** | 3~6 | ≥6 | ≥3000 | ≥80 | ≥2800 |          |
| **result** | 6.0 | 4.2 | 9.32 | 7820 | 92.3 | 3200 |

**Construction Process and Quality Control**

**Preparation of Composite Modified Asphalt Mixture**

Because the viscosity of waste rubber powder/SBS composite modified asphalt is slightly higher than that of ordinary asphalt, the mixing time of this asphalt mixture is slightly longer than that of ordinary asphalt mixture. In general, the dry and wet mixing time is about 5 to 15 seconds longer than that of ordinary asphalt mixtures. The specific extension time is based on the principle that the mixture is uniformly mixed and that the mineral particles are all covered with asphalt.

The waste rubber powder/SBS double composite modified asphalt is slightly more viscous than ordinary asphalt, so the viscosity corresponding temperature to meet the construction requirements is slightly higher than that of ordinary asphalt, therefore, the temperature of each link in the production and mixing of its mixture needs to be increased by 10 to 15 °C. When the 180 °C Brinell rotational viscosity of the waste rubber powder/SBS modified asphalt is measured to be higher than 3.0 Pa.s, the processing temperature should be further increased by about 5-10 °C.

Waste rubber powder/SBS double composite modified asphalt has a relatively high viscosity and is stored in asphalt tanks, but due to the characteristics of rubber powder, it is easy to precipitate,
which affects the heat dissipation of heat transfer pipes. Therefore, the temperature of the asphalt tank is difficult to rise, and the commonly used storage tank asphalt pump is difficult to transport the rubber powder modified asphalt to the mixing building, and it needs to be simply modified and processed. The double-composite modified asphalt used in the test section of this topic is produced by factory processing and stored in an asphalt tank for future use. Its temperature is difficult to quickly rise to the temperature required by the mixing building, thereby affecting the production efficiency of the asphalt mixture. Therefore, it is recommended that the finished rubber powder and SBS composite modified asphalt be quickly transported to the mixing building at a higher temperature in subsequent use, so as to avoid the problem that the temperature of the composite modified asphalt is difficult to rise and its quality.

Transportation of Composite Asphalt Mixture

The waste rubber powder / SBS composite modified asphalt mixture should be transported using a clean dump truck, and the mixture should not be polluted. The number of vehicles needs to be determined according to the transportation distance and the current situation of road traffic to ensure that a continuous flow of supply vehicles is formed before the paver. At the same time, an appropriate amount of release agent should be applied to the side plates and the bottom plate of the asphalt mixture carriage. It is forbidden to use pure petroleum products. When oil-water mixture is used, the oil-water ratio must be strictly controlled.

Segregation of coarse and fine mixtures is avoided by moving the material carrier forward and backward. A thermal insulation layer is provided for the bulk measurement of the carriage body, and the top surface is covered with a double-layer waterproof thick tarpaulin for sealing and insulation.

The transporter should ensure that the paver is oriented backwards to the paver and stopped when it is about to reach the front roller of the paver. Continue to move forward after the truck releases the brakes and make contact with the truck to push the pull forward, which can help reduce scoring. Increasing the mixture transfer vehicle can effectively reduce the adverse effects of mixture separation and transportation.

Paving of Composite Asphalt Mixture

The paving temperature of the waste rubber powder/SBS double compound modified asphalt mixture is slightly higher than that of general asphalt mixture. The outside temperature of the paving of the upper layer mixture is generally required to be above 15 °C, so as to effectively cope with the temperature of the thin thickness and the rapid loss. At the same time, even and continuous paving in accordance with the specifications to ensure the smoothness of the road surface. The paving speed can be flexibly adjusted at any time according to conditions such as paving thickness and width. During the paving process, continuous pavement should be tried as much as possible, and the speed should not be stopped or changed arbitrarily, and the speed should be appropriately slower, because the production efficiency of composite modified asphalt is low, and the phenomenon of insufficient supply may occur.

In order to ensure the paving quality of the pavement, a material truck is used in conjunction with the paving. This can reduce the problem of separation of the mixture during the paving process and can add the new mixture before separating the mixture in the hopper before it is sent to the distribution chamber.

Rolling of Mixture

The laying of waste rubber powder/SBS double-composite modified asphalt mixture requires that vibration rolling be turned on when the temperature of the mixture is high, and the initial pressure must follow the paver, and the compaction must be above 95%. The number of vibration passes is determined according to the site conditions of the mixture in the paver. The rolling section requires a clear hierarchy, and the mark demarcation must be clearly set. In order to effectively distinguish the limits of the initial pressure, the repeated pressure, and the final pressure, an identification plate can be inserted on the side of the shoulder of the rolling section. The rolling direction and route
remain the same. The opening vibration should start after the roller is started, stop the vibration and then stop driving. There are rust marks on the surface of the roller of the road roller, and the rust must be removed in advance. Traffic can be opened when the road temperature is lower than 50 °C and the time exceeds 24 hours.

**Conclusion**

(1) The waste rubber powder/SBS double compound modified asphalt has good performance in the application of Yangquan to Zuoquan Expressway, and the rutting stability reaches 7800 times/mm, which is far greater than the requirement of more than 3000 times/mm, and its water stability performance and low temperature bending performance also meet the requirements of the index.

(2) The dry mixing and wet mixing time of the waste rubber powder/SBS double composite modified asphalt concrete is about 5 to 15 seconds longer than that of dry mixing and wet mixing.

(3) In the mixing of waste rubber powder/SBS double compound modified asphalt mixture, it is generally appropriate to increase the temperature of each link by 10 to 15 °C.

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